WHITE PAPER

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Active Management of Blue Mountains Dry Forests: Silvicultural Considerations

David C. Powell; Forest Silviculturist
Supervisor's Office; Pendleton, OR

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Excellent stand of ponderosa pine, Grant County, Oregon (Munger 1917)

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COVER PHOTOGRAPH: Excellent stand of western yellow pine in Grant County, Oreg.; Showing the variety in size and age of the trees, the openness of the forest, the plentiful herbage beneath the trees, and the abandance of seedlings in groups, characteristic of Blue Mountain timber (image appears before page 17 in Thornton T. Munger's classic 1917 bulletin: Western Yellow Pine in Oregon).

1. INTRODUCTION

A Blue Mountains ecoregion extends from Ochoco Mountains in central Oregon to Hells Canyon of Snake River in extreme northeastern Oregon, and then north to deeply carved canyons and basalt rimrock of southeastern Washington (fig. 1).

An objective of this white paper is to discuss silvicultural considerations associated with active management of Blue Mountains dry forests.

A companion white paper (F14-SO-WP-Silv-7) discusses silvicultural considerations for active management of Blue Mountains moist upland forests (Powell 2019a).

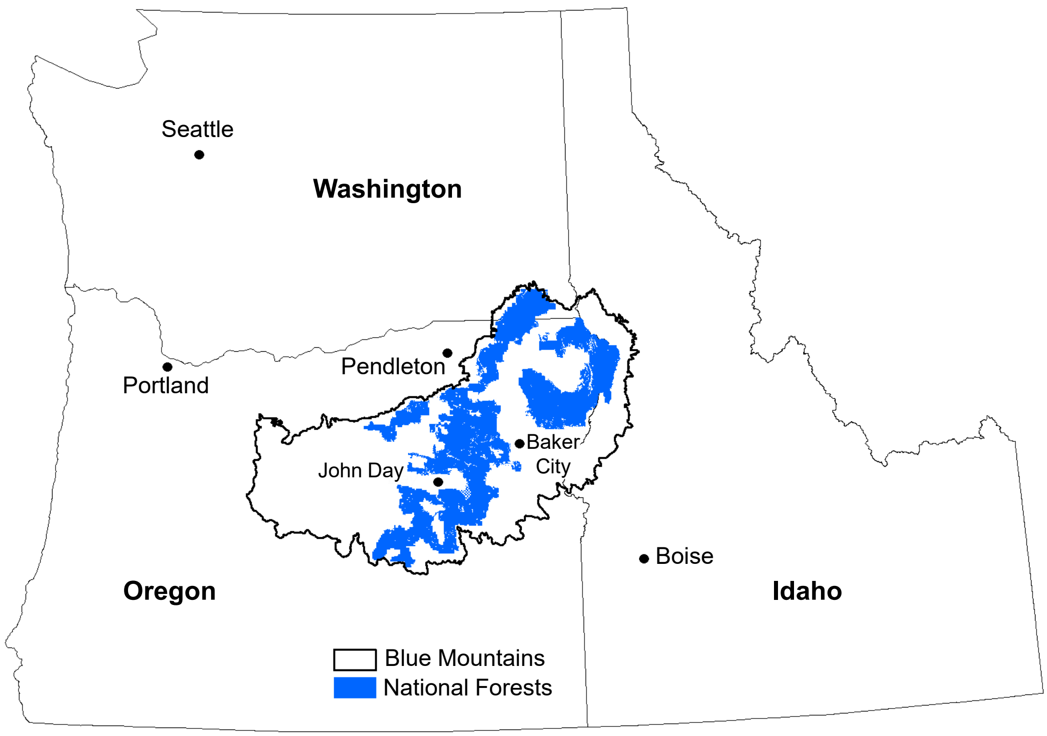


Figure 1 – Blue Mountains ecoregion of northeastern Oregon, southeastern Washington, and west-central Idaho. This ecoregion consists of a series of mountain ranges in a southwest to northeast orientation, extending from Ochoco Mountains in central Oregon, southwestern portion of the ecoregion, to western edge of Seven Devils Mountains in west-central Idaho, northeastern portion of the ecoregion. Blue shading shows spatial extent of Malheur, Umatilla, and Wallowa-Whitman national forests in Blue Mountains ecoregion.

Beginning in mid-1960s, Blue Mountains experienced a series of insect outbreaks, disease epidemics, and wildfires. These disturbance events were viewed as unusually severe because they caused great amounts of damage or affected more area than was typical. Blue Mountains eventually gained a dubious distinction of having perhaps the worst forest health in western United States (Durbin 1992; East Oregonian 1992; Gray and Clark 1992; Kenworthy 1992; Lucas 1992, 1993; McLean 1992; Peterson 1992; Phillips 1995; Richards 1992).

Articles in magazines and newspapers contributed to a public perception that Blue Mountains were experiencing a forest health crisis of unprecedented magnitude. This perception led to a series of broad-scale scientific assessments examining forest health effects and their underlying causes (Caraher et al. 1992, Gast et al. 1991, Henjum et al. 1994, Hessburg et al. 1999a, Johnson 1994, Lehmkuhl et al. 1994, Mutch et al. 1993, Quigley 1992, Quigley et al. 1996, Schmidt et al. 1993, Tanaka et al. 1995, Wickman 1992).

Among other things, 1990s scientific assessments concluded that:

- In 1980s, an unusually severe outbreak of western spruce budworm, a defoliating insect whose habitat is mixed-conifer forest, functioned as a symptom of impaired forest health for Blue Mountains, particularly for dry forest environments (Caraher et al. 1992, Gast et al. 1991, Johnson 1994, Mutch 1994, Powell 1994, Quigley 1992, Schmidt et al. 1993, Tanaka et al. 1995, Wickman 1992).
- It soon became apparent that budworm defoliation and other conditions contributing to a Blue Mountains forest health crisis were also occurring throughout interior Pacific Northwest and elsewhere in western United States, particularly for dry forest environments (Everett et al. 1994; Hessburg et al. 1994, 1999a; Lehmkuhl et al. 1994; O'Laughlin et al. 1993, Oliver et al. 1994c; Quigley et al. 1996; Sampson and Adams 1994).
- Fine-scale project planning corroborated findings from broad-scale assessments by suggesting that certain symptoms of impaired forest health (such as uncharacteristic wildfire and insect effects) were largely related to species composition, forest structure, and tree density being outside their historical range of variation. Once again, this finding pertained mostly to dry-forest portions of Blue Mountains ecoregion.

We know that many of our fire-dependent, dry-forest ecosystems are deteriorated, with wildfire and other disturbance processes behaving much differently now than they did historically. This white paper examines causes, effects, and possible responses to dry-forest deterioration, and it does so by using the following analytical framework (Egan and Howell 2001):

1. Define an ecological setting and historical context for dry-forest ecosystem components (species composition, forest structure, and tree density).
2. Identify some factors (fire suppression, ungulate herbivory, selective cutting) that may have contributed to dry-forest ecosystem changes through time.
3. Describe what needs to be done to restore dry-forest ecosystem components.
4. Develop criteria for measuring success of restoration activities.

Initial sections of this white paper characterize an ecological setting and provide an historical narrative for dry forests. Middle sections examine how fire exclusion, plant succession in an absence of recurrent fire, domestic and native ungulate herbivory, and selective timber harvest allowed historically high resilience of dry-forest ecosystems to erode to low levels. Final sections describe restoration options for dry-forest ecosystems, including how active management treatments could be applied in such a way as to help recover some of their lost resilience.

Scope of this white paper is dry upland forests, a biophysical environment found predominantly on southern half of Umatilla National Forest and elsewhere in the central and southern Blue Mountains, and to a lesser extent on northern half of Umatilla National Forest and elsewhere in the northern Blue Mountains (fig. 2, table 1).

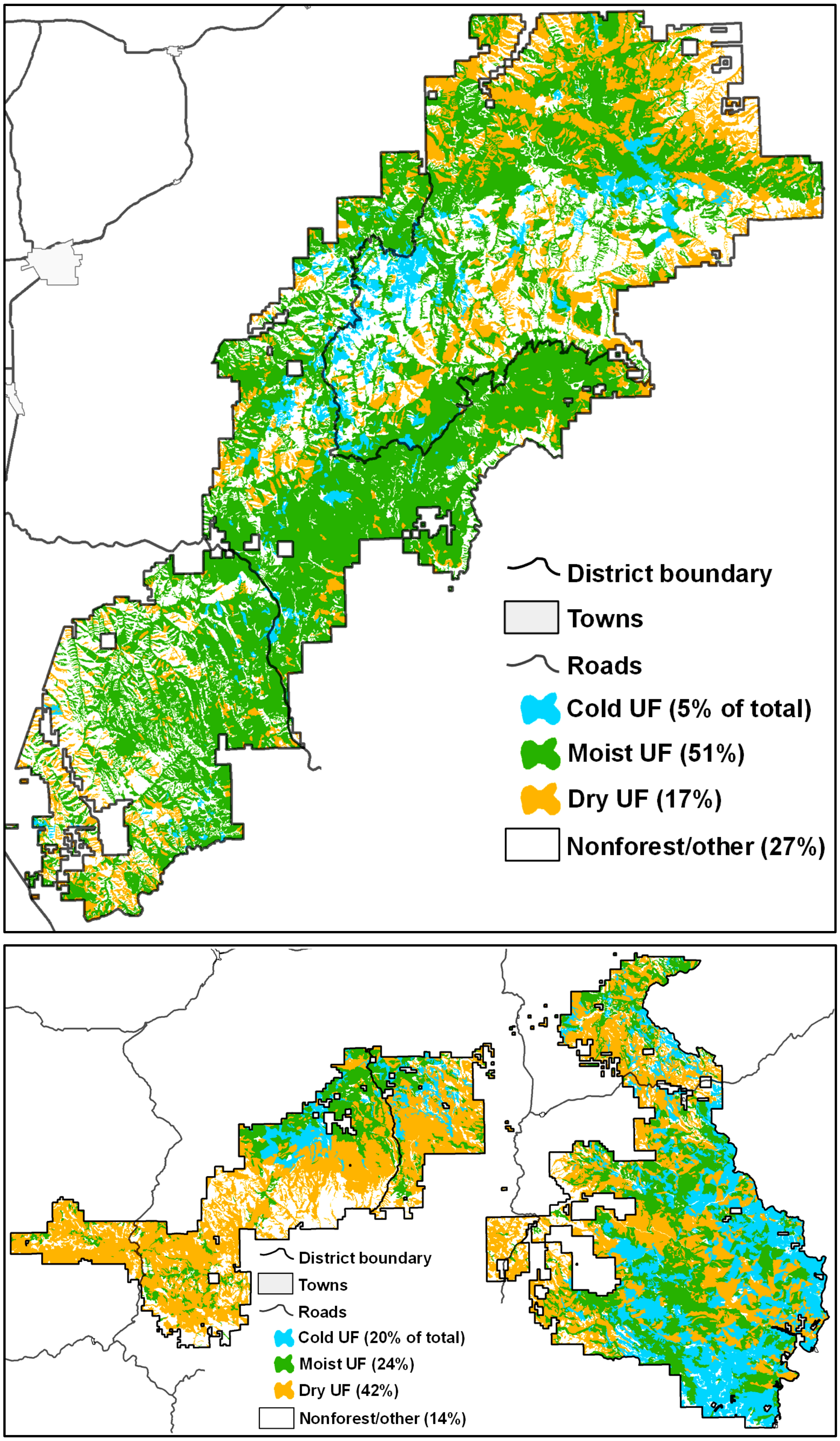


Figure 2 – Distribution of upland forest (UF) potential vegetation groups on Umatilla National Forest (north-end districts above; south-end districts below).

Table 1: Acreage summary for upland forest potential vegetation groups of Umatilla National Forest.

Potential Vegetation Group	North Half	South Half	Total
Cold Upland Forest	34,832 ac (21%)	132,314 ac (79%)	167,145
Pct. Of Forested	7%	23%	15%
Pct. Of Total	5%	20%	12%
Moist Upland Forest	368,847 ac (70%)	162,283 ac (30%)	531,130
Pct. Of Forested	70%	28%	48%
Pct. Of Total	51%	24%	38%
Dry Upland Forest	123,129 ac (30%)	286,316 ac (70%)	409,445
Pct. Of Forested	23%	49%	37%
Pct. Of Total	17%	42%	29%
Nonforest	201,481 ac (68%)	94,667 ac (32%)	296,147
Pct. Of Total	27%	14%	21%

Sources/Notes: Derived from spatial data available in Umatilla National Forest geographical information system.

Appendix 1 provides a list of potential vegetation types (plant associations, plant community types, plant communities) occurring in a dry upland forest potential vegetation group.

Appendix 1 demonstrates that to establish a context for this white paper, dry forest is defined by using units of potential vegetation (e.g., plant associations, plant community types, plant communities), rather than by adopting an alternative approach relying on categories of existing vegetation (such as ponderosa pine stands or cover types, etc.).

This strategy for defining dry forest is necessary because potential vegetation reflects site potential – vegetation types a site can support under contemporary climate and its associated temperature and moisture regimes. Existing vegetation, however, describes what is present now, regardless of whether it represents climatic (permanent) vegetation or temporary types resulting from wildfire, timber harvest, ungulate grazing, and other disturbance processes.

Formatting note: glossary terms are dispersed throughout this white paper by separating them from text in gray-shaded sections (see first example, below). This approach was adopted to provide definitions in the chapter in which a term is first used, rather than combining all glossary terms in one section at the end of this document.

Active management. Human intervention into nature, extent, and timing of disturbance to forest ecosystems for the purpose of obtaining desired goods and services (Haeussler and Kneeshaw 2003).
Resilience. Intrinsic properties allowing fundamental functions of an ecosystem to persist in the face of extremes of disturbance. Resilience recognizes that systems have a capacity to absorb disturbances, but this capacity has limits and bounds, and when they are exceeded, a system may rapidly transform to a different state or developmental trajectory (Gunderson et al. 2010).

2. ECOLOGICAL SETTING

A distant summer view of the Blue Mountains shows a dark band of coniferous forest occurring above a lighter-colored grassland zone. Each of the two contrasting areas seems to be homogeneous, and the border between them appears sharp. A closer view reveals great diversity within each zone (fig. 3) and borders that are poorly defined: herbaceous communities and stands of deciduous trees are scattered throughout the coniferous forest, and the species of dominant conifer changes from one site to another (Powell 2000).

At the foot of the Blue Mountains, fingers of forest and ribbon-like shrub stands invade the grassland zone for varying distances before becoming progressively less common and eventually disappearing altogether. This vegetation pattern indicates that the Blue Mountains are actually broken up into a myriad of small units, many of which repeat in an intricate, changing pattern. Making sense of this landscape mosaic is possible by using a concept called potential vegetation (Powell 2000).

Potential vegetation is defined as the community of plants that would become established if all successional sequences were completed, without interference by humans, under existing environmental conditions (Hall et al. 1995). It also implies that over the course of time and in the absence of disturbance, similar types of plant communities will develop on similar sites (Pfister and Arno 1980).

For the Blue, Ochoco, and Wallowa mountains of northeastern Oregon and southeastern Washington, potential vegetation has been organized into two closely related hierarchies – a fine-scale hierarchy useful for project planning (Hall 1989), and a mid-scale hierarchy ideally suited for strategic assessments (Johnson et al. 1999, REO 1995).

A mid-scale potential vegetation hierarchy has three levels: physiognomic classes, potential vegetation groups, and plant association groups (Powell et al. 2007). Since plant associations (potential vegetation types) are aggregated to form plant association groups, plant association provides a link between the fine- and mid-scale hierarchies (fig. 4).

Potential vegetation (PV) is used to classify biophysical environments because it has an important influence on ecosystem processes. It is an ecological engine that powers vegetation change – it controls the speed at which shade-tolerant species get established beneath shade-intolerant trees, rates at which forests produce biomass, and effects of fire, insects, pathogens, and other disturbance agents on ecosystem composition and structure. Implications of these processes are predictable (within limits) because they are related to PV, and sites with similar PV behave in a similar way (Cook 1996, Daubenmire 1961).

Because of its predictive power, PV is useful for estimating the impact of disturbance processes and management activities on differing ecological environments. For example, a prescribed fire with a flame length of 2 feet and a fireline intensity of 25 BTU/ft/sec has relatively benign, nonlethal results when used on dry sites where overstory trees have thick bark (ponderosa pine, Douglas-fir, western larch). The same activity has dramatically different results (near-complete tree mortality) on cold sites dominated by thin-barked firs and lodgepole pines.

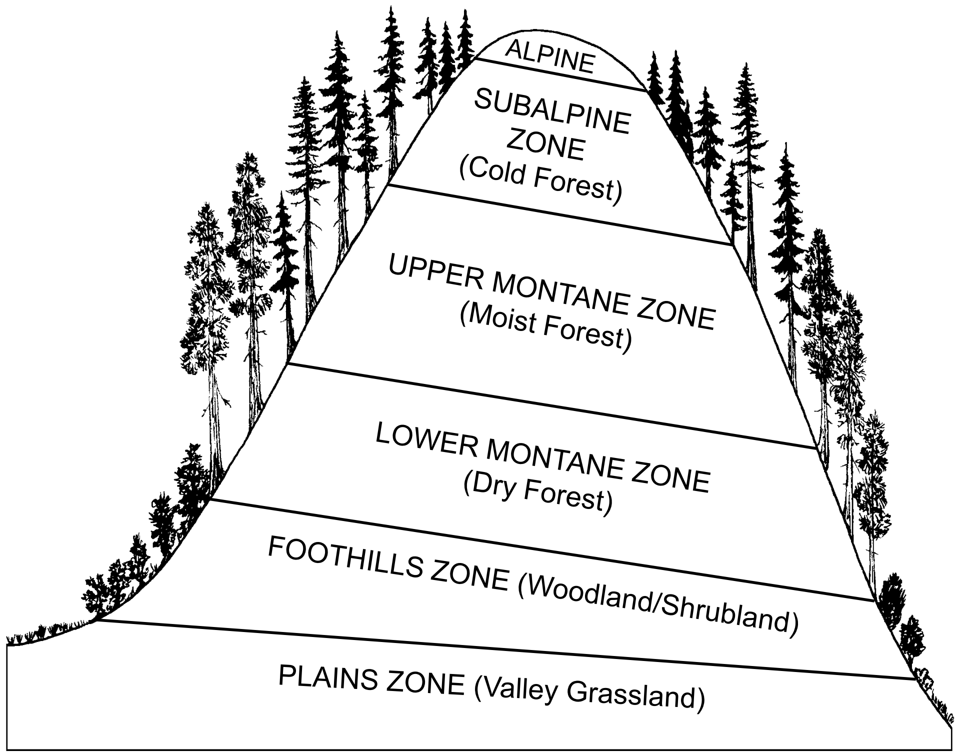


Figure 3 – Vegetation zones of the Blue Mountains. In the northern hemisphere, a south-facing slope receives more solar radiation than a flat surface, and a north-facing slope receives less (south slope is to the left, and north is to the right). These solar radiation patterns result in vegetation zones or bands shown here – they are arranged vertically in response to elevation (moisture), and sloping downward from south to north (left to right) in response to slope direction or aspect (temperature).

A plains zone contains grasslands and shrublands because moisture is too low to support forests except along waterways. A foothills zone is usually dominated by western juniper, often with a mixture of mountain-mahogany shrublands. Located just above western juniper woodlands is a lower montane zone containing dry mixed-conifer forests in the ponderosa pine, Douglas-fir, and grand fir potential vegetation series (dry mixed-conifer forests are the subject of this white paper). This dry mixed-conifer zone consists of 3 dry grand fir types, 21 ponderosa pine types, and 11 dry Douglas-fir types (plus a few other miscellaneous types; see appendix 1). An upper montane zone includes moist forests in the Douglas-fir, grand fir, and subalpine fir series. High elevations support a subalpine zone with Engelmann spruce and subalpine fir, or an alpine zone near mountain summits where trees are absent. Neither subalpine nor alpine environments are common in the Blue Mountains, a relatively low-elevation range.

Potential vegetation group (PVG). An aggregation of plant association groups (PAGs) with similar environmental regimes and dominant plant species. Each group (PVG) typically includes PAGs representing a predominant temperature or moisture influence (Powell et al. 2007). The scope of this white paper is the Dry Upland Forest PVG.
Plant association group (PAG). Groupings of plant associations (and related potential vegetation types such as plant communities and plant community types) representing similar ecological environments as characterized by using temperature and moisture regimes. Most common PAG in a Dry Upland Forest PVG is the Warm Dry Upland Forest PAG. [Both definitions derived from Powell et al. (2007).]

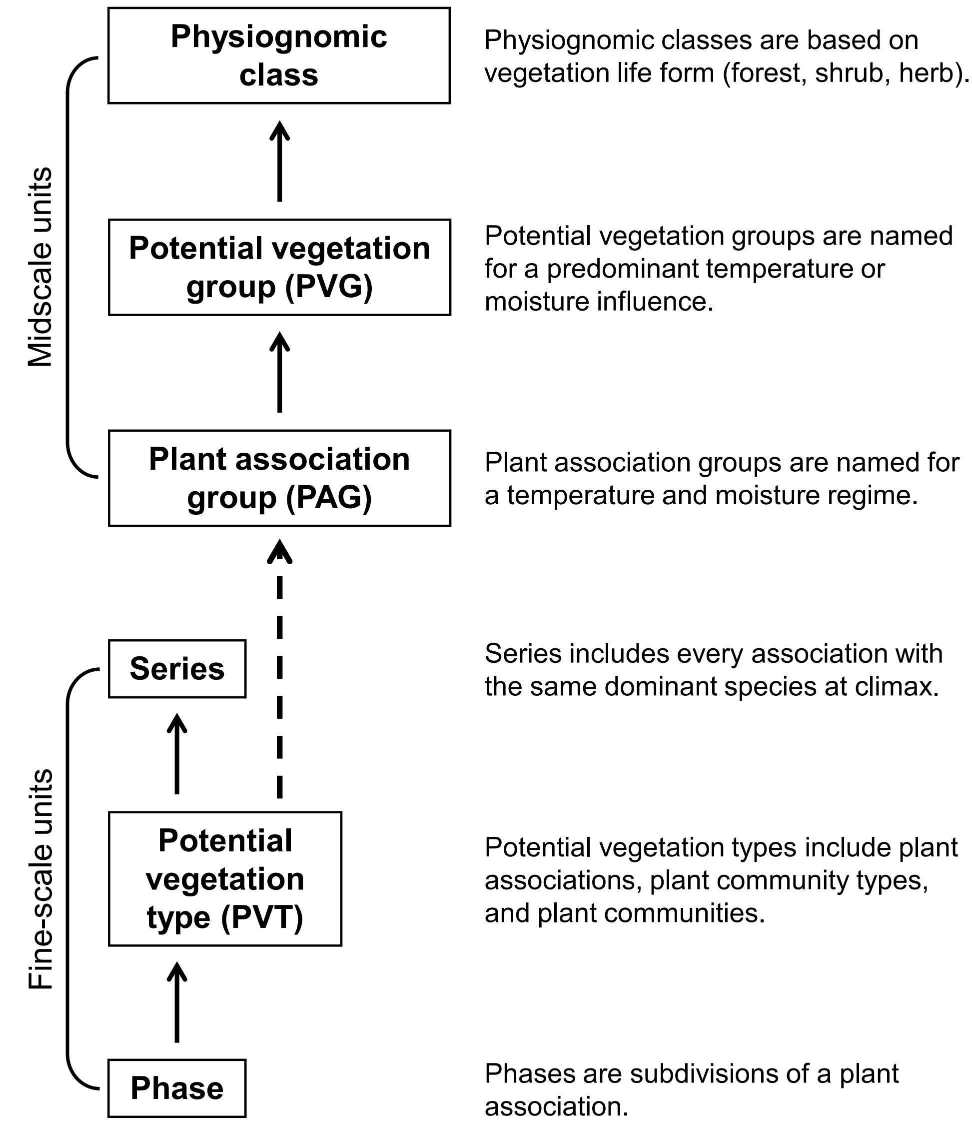


Figure 4 – Hierarchy of potential vegetation (PV) for Blue Mountains (from Powell et al. 2007). PV taxonomic units have been organized as two integrated portions of a hierarchy. Fine-scale hierarchical units are described in PV classification reports and their associated keys (Crowe and Clausnitzer 1997, Johnson 2004, Johnson and Clausnitzer 1992, Johnson and Simon 1987, Johnson and Swanson 2005, and Wells 2006). Potential vegetation types (PVTs) provide a link between fine- and mid-scale portions of the hierarchy because PVTs are aggregated to form plant association groups.

Primary biophysical environment covered by this white paper is referred to as Dry Upland Forest potential vegetation group (PVG). Dry Upland Forest is one of three potential vegetation groups occurring in an Upland Forest physiognomic class (other two PVGs in this physiognomic class are Moist Upland Forest and Cold Upland Forest). PVT codes and names, and a plant association group that each Dry Upland Forest PVT has been assigned to, are provided in appendix 1 of this white paper.
[As illustrated in this figure, plant association groups (PAGs) occur at a lower level in the hierarchy than PVGs – Dry Upland Forest PVG contains three PAGs, each named for a combination of temperature and moisture conditions – warm dry (by far the most common PAG in Dry Upland Forest PVG), hot moist, and hot dry.]

2.1 Dry Upland Forest Potential Vegetation Group

Dry upland forests occur at low to moderate elevations of a montane vegetation zone. Late-seral stands are dominated by ponderosa pine, grand fir, or Douglas-fir as climax species; ponderosa pine or Douglas-fir function as early- or mid-seral species depending on plant association. Western juniper is expanding into this PVG as a result of fire exclusion and climate change (Gedney et al. 1999, Quigley et al. 1996), moving upward from a woodland zone below the montane zone. Dry forests are adjoined by moist upland forests at their upper edge, and by woodlands and shrublands of a foothills vegetation zone at their lower edge (fig. 3).

For the Blue Mountains, a Dry Upland Forest PVG consists of three plant association groups (PAG) – one from a warm temperature regime (Warm Dry PAG), and two from a hot temperature regime (Hot Moist and Hot Dry PAGs). Of these three PAGs, Warm Dry is most common for Dry UF potential vegetation group. A warm dry PAG supports dry mixed-conifer forests, with 3 dry grand fir potential vegetation types, 21 ponderosa pine potential vegetation types, and 11 dry Douglas-fir potential vegetation types (plus other miscellaneous types; see appendix).

Warm, dry forests are the most common forest zone of the Blue Mountains, and because they occur at the lowest forested elevations, they have a long history of human use – both for commodity purposes (including timber harvest and domestic livestock grazing), and as an area where effective fire exclusion occurred early on and eventually led to obvious changes in species composition, forest structure, and stand density. Dry-forest sites were historically dominated by ponderosa pine because it is well adapted to persist in a fire regime featuring low-severity fires occurring every 5 to 20 years (Agee 1996b; Hall 1976, 1980).

Common dry-forest undergrowth species feature graminoids and mid-height shrubs. Elk sedge and pinegrass are ubiquitous graminoids, while birchleaf spiraea, snowberry, ninebark, and bitterbrush are common shrubs. On very dry sites, a Dry UF PVG has mountain-mahogany, big sagebrush, bluebunch wheatgrass, and western juniper (Hot Dry PAG).

Insect and disease agents of notable importance for dry-forest sites include defoliating insects such as western spruce budworm and Douglas-fir tussock moth (but only in those situations where Douglas-fir and grand fir invaded stands historically dominated by ponderosa pine), Douglas-fir dwarf mistletoe, and western dwarf mistletoe and bark beetles in ponderosa pine.

Why Discuss Dry Forest As A Separate Entity?

Why prepare a white paper focused just on dry forests? After all, dry forests exist in a mosaic – sometimes they are a dominant landscape element (matrix), and at other times, they exist as patches within a moist-forest matrix. From many perspectives, it makes sense to examine an entire mosaic rather than its constituent parts (dry forest, moist forest, etc.). Dry-forest ecosystems, however, are molded by disturbance processes differing in important ways from those shaping moist- or cold-forest environments. Thus, the science informing dry forests also differs from science relating to moist-forest management. This truth is demonstrated by examining dry- and moist-forest white papers – there is little science overlap between them (except for science pertaining to concepts and principles), and substantial overlap is not expected when considering their ecological and historical (management) settings.

3. HISTORICAL CONTEXT

When Euro-Americans pushed up the Oregon Trail into the Blue Mountains of northeastern Oregon in mid-1800s, they encountered a strikingly beautiful forest unlike any they had seen on their way west (fig. 5). Widely spaced ponderosa pines formed a towering canopy over an understory so free of brush and small trees that settlers could often drive their wagons through the forest as if it was a carefully manicured park (Evans 1991, Kenworthy 1992, Murphy 1994).

Oregon Trail diarist Rebecca Ketcham described an open condition well in her journal entry for Tuesday, September 6, 1853, written just after her party left the Grande Ronde River valley near La Grande, Oregon as they continued their journey to the northwest (Evans 1991):

> "Our road has been nearly the whole day through the woods – that is, if beautiful groves of pine trees can be called woods. I can almost say I never saw anything more beautiful, the river winding about through the ravines, the forests so different from anything I have seen before. The country all through is burnt over, so often there is not the least underbrush, but the grass grows thick and beautiful. It is now ripe and yellow and looks like fields of grain ripened, ready for the harvest."

Rebecca Ketcham was not the only emigrant who noticed fire's influence on vegetation conditions along the Oregon Trail. When 66 accounts from a book synthesizing journals by 19th century travelers on the Blue Mountains portion of the Oregon Trail (Evans 1991) were analyzed, 89% of them referred to open ponderosa pine stands, and 54% noted burned underbrush or grassy glades, much smoke in late summer and fall, or a lack of underbrush or dense tree thickets (Wickman et al. 1994).

Selected passages from Evans' book describing fire and vegetation conditions are provided below; misspellings from original journals are retained in these excerpts (Evans 1991):

> "…the grass has been lately consumed, and many of the trees blasted by the ravaging fire of the Indians. These fires are yet smouldering, and the smoke from them effectually prevents our viewing the surrounding country, and completely obscures the beams of the sun."
> *Journal of John Kirk Townsend, August 31, 1834*

> "Came to trees, at first quite thin & without underbrush having fine grass. But as we arose we came to a densly timbered country, mostly pine & fir. The most beautiful tall straight trees. Our traviling through the timber was quite difficult as the path wound back and forth and many logs lay across it."
> *Journal of Medorem Crawford, September 12, 1842*

> "They [mountains] are mostly covered with high bunch grass, which at this season is quite dry. This often gets on fire, burning for miles and days together. One of these burnings is in sight of us today. It is on the opposite side of the river from us, or I should feel alarmed.
>
> The fire in the mountains last night was truly grand. It went to the tops of them spreading far down their sides. We were obliged to go over after our cattle at dark and bring them across the stream. The fire extended for several miles, burning all night, throwing out great streamers of red against the night sky. This morning there is none visible."
> *Journal of Esther Hanna, August 15-16, 1852*

Figure 5 – Open ponderosa pine forest with herbaceous undergrowth (stand of old-growth *P. ponderosa* near Whitney, Oregon, ca. 1900 [J.W. Cowden]; courtesy Gary Dielman, Baker City library). Pioneer journals (Beckham 1991, Evans 1991), early forestry surveys (Gannett 1902, Munger 1917), and fire history studies (Heyerdahl 1997, Maruoka 1994) suggest that many Blue Mountain dry-forest sites had presettlement conditions similar to those depicted in this image, particularly for Douglas-fir/pinegrass and grand fir/pinegrass plant associations (Weaver 1967a, b). These biophysical settings feature a warm and dry temperature-moisture regime, and in combination with a disturbance regime dominated by frequent surface fires, they promote and maintain a distinctive species composition and stand structure, as shown here.

According to these journal accounts, forest conditions at low and middle elevations consisted mainly of ponderosa pine, pine forests were open and park-like with grass and herbs as predominant undergrowth vegetation, and fire was a common occurrence in late summer and autumn (Beckham 1991, Evans 1991, Wickman et al. 1994). We can surmise that a typical landscape pattern was a fine-scale mosaic of stands of varying ages and stages of development, with young stands a result of infrequent, stand-replacing fires or bark-beetle outbreaks.

H.D. Foster (1908) described an open, park-like condition well when he observed, "the forest floor is open, free from underbrush in any quantity, so much so that it is possible to ride in almost any direction through the forest without following trails."

It is widely reported that the Blue Mountains were named to commemorate a bluish haze enveloping them during late summer and fall when fires were burning (Mutch et al. 1993). Two journal entries below (Beckham 1991, Evans 1991), however, speculate that their name commemorates a blue-green hue imparted by extensive pine stands. In either case, fire was important for a 'Blue Mountains' name because it not only created smoke, but it also maintained ponderosa pine forests that would have been rare without underburning.

> "It is probable that they have received their name of the Blue mountains from the dark-blue appearance given to them by the pines."
> *Journal of Captain John Charles Fremont, October 17, 1843*.

> "I presume these mountains take their name from their dark blue appearance being densely timbered with pine timber, which being ever green gives the forest a sombre appearance, besides the limbs of the trees are all draped with long festoons of dark colored moss or mistletoe." *Journal of John or David Dinwiddie, August 30, 1853*.

Almost fifty years after Rebecca Ketcham's observations, scientist and geographer Henry Gannett examined Oregon's forests during a survey of federal forest reserves. Fire's effect on vegetation was clearly recognized during his survey, as described below (Gannett 1902):

> "The burns are greatest and most frequent in the most moist and most heavily timbered parts of the state, and are smaller and fewer where the rainfall is less and where the timber is lighter. This is owing to the density and abundance of the undergrowth in the heavily forested regions, which feeds the fire and vastly increases its heat.
>
> In the comparatively sparsely timbered southern portions of the Coast Range and the Cascades and in the Blue Mountains, where the forests are largely or mainly of yellow pine in open growth, with very little litter or underbrush, destructive fires have been few and small, although throughout these regions there are few trees which are not marked by fire, without, however, doing them any serious damage."

3.1 Ponderosa Pine In Eastern Oregon

Thornton T. Munger, first director of USDA Forest Service's Pacific Northwest Research Station, examined eastern Oregon's ponderosa pine forests more than a decade after Gannett's survey. Munger made insightful observations about forest structure and composition, including frequent comments about fire's obvious influence (Munger 1917):

> "In most of the pure yellow-pine forests of the State the trees are spaced rather widely, the ground is fairly free from underbrush and debris, and travel through them on foot or horseback is interrupted only by occasional patches of saplings and fallen trees. The forests are usually not solid and continuous for great distances, except along the eastern base of the Cascades, but are broken by treeless 'scab-rock ridges,' or natural meadows.
>
> In the Blue Mountains the herbage is rather more luxuriant and varied than on the eastern slopes of the Cascades and their outstanding ranges. In the early summer the open yellow-pine forests are as green with fresh herbage as a lawn, except here and there where the green is tinged with patches of yellow or purple flowers. Some of this luxuriant herbage is pine grass (*Calamagrostis* sp.), a plant which is not eaten by stock except very early in the season; but much of the ground cover makes excellent range for cattle and sheep.
>
> In the Blue Mountains western larch (*Larix occidentalis*) is its [western yellow pine] usual companion and grows with it in an intimate and harmonious mixture. In the moister situations white fir (*Abies concolor*) is a common associate, as is also Douglas fir (*Pseudotsuga taxifolia*) in most parts of the State. In the Blue Mountains it is common for the south slopes to be covered

with a fine stand of yellow pine, while the north slopes are covered almost entirely with larch, white fir, and Douglas fir.

In the Blue Mountains the reproduction of yellow pine is very abundant, both in the virgin forest and after cuttings. Perhaps it is more prolific here than anywhere else. In this region where an area has not been burned over by a surface fire for a number of years, there is quite commonly a veritable thicket of little trees from a few inches to several feet high. Actual counts have shown that there are sometimes 14,000 seedlings on a single acre, the ages ranging from 13 to 21 years.

Yellow pine grows commonly in many-aged stands; i.e., trees of all ages from seedlings to 500-year-old veterans, with every age gradation between, are found in intimate mixture. Usually two or three or more trees of a certain age are found in a small group by themselves, the reason being that a group of many young trees usually starts in the gap which a large one makes when it dies.

Light, slowly spreading fires that form a blaze not more than 2 or 3 feet high and that burn chiefly the dry grass, needles, and underbrush start freely in yellow-pine forests, because for several months each summer the surface litter is dry enough to burn readily. Practically every acre of virgin yellow-pine timberland in central and eastern Oregon has been run over by fire during the lifetime of the present forest, and much of it has been repeatedly scourged.

It is sometimes supposed that these light surface fires, which have in the past run through the yellow-pine forests periodically, do no damage to the timber, but that they 'protect' it from possible severe conflagrations by burning up the surface debris before it accumulates. This is a mistake. These repeated fires, no matter how light, do in the aggregate an enormous amount of damage to yellow-pine forests, not alone to the young trees, but to the present mature merchantable timber.

A careful cruise of every tree on 154½ sample acres in typical yellow-pine stands in several localities in the Blue Mountains showed that 42 out of every 100 trees were fire-scarred.

Ordinarily, a fire in yellow-pine woods is comparatively easy to check. Its advance under usual conditions may be stopped by patrolmen on a fire line a foot or so wide, either with or without backfiring. The open character of the woods makes the construction of fire lines relatively easy, and in many places horses may be used to plow them."

And when Munger examined eastern Oregon's ponderosa pine forests in 1910-1911, an open park-like structure was clearly evident (Munger 1917):

"In pure, fully stocked stands in the Blue Mountains region there are commonly from 20 to 30 yellow pines per acre over 12 inches in diameter, of which but few are over 30 inches. Over large areas the average number per acre is ordinarily less than 20."
[Note: 20 trees per acre results in an equilateral (triangular) spacing of 50 feet between trees, most assuredly an open stand condition. This equilateral spacing calculation is provided for a tree density context – presettlement ponderosa pine stands did NOT feature individual trees growing at a regular spacing of 50 feet apart. A common structural condition was large ponderosa pine trees occurring in clumps or groups, as illustrated in photographs used for figures 44-46 later in this white paper. Since trees tended to be aggregated as clumps, spacing between individual clumps was typically greater than 50 feet.]

George Bright offered similar observations about an open character for ponderosa pine forests, along with five specific causes for its open structure (Bright 1914):

> "The most striking feature of a stand of Western Yellow pine is its open character. The peculiarity is the first thing which strikes anyone looking upon such a forest for the first time. Even growing on the best soils and under favorable climatic conditions, it would be difficult, if not quite impossible, to find a full or normal stand of Yellow pine over an area of forty or even ten acres. There appear openings even where the very best conditions for growth of this tree occur, as well as in localities where conditions are less favorable. The peculiarity of Yellow pine stands is due to five primary causes, as follows: (1) fire, (2) insect infestation, (3) windfall, (4) root competition and (5) light competition."

George Bright and Thornton Munger worked together to install plots in Blue Mountains ponderosa pine type in 1910 and 1911 (Bright 1912, Munger 1912). Bright summarized plot results in a published journal paper (Bright 1914). Unfortunately, plot results were only provided for merchantable trees, which included stems 12 inches in diameter and greater.

Even though it lacks information for trees smaller than 12 inches, Bright's summary provides a useful stand density reference condition for mature, large-diameter ponderosa pines. A lack of reference condition information for the regeneration component (e.g., seedlings, saplings, and poles) is unfortunate because it would have provided a much more complete picture for presettlement dry-forest structure.

Presettlement stand densities of mature ponderosa pines on eight dry-forest plots from three localities in the Blue Mountains are provided in table 2.

Table 2: Historical tree density information for 8 plots and 3 localities in the Blue Mountains.

Plot Locality	Plot Size (Acres)	Total Number of Trees on Plot[1]	Trees per Acre[1]	Average Tree Diameter (Inches)[1]	Basal Area per Acre[1]	SDI
Palmer Junction	5	170	34	21	82	126
Palmer Junction	5	190	38	23	110	166
Palmer Junction	4	119	30	19	59	93
Palmer Junction	4	176	44	19	87	137
Palmer Junction	6	159	27	21	63	99
Whitney	20	669	33	21	80	124
Whitney	10	301	30	22	79	122
Austin	4	124	31	22	82	125
Mean	7	239	33	21	80	124

[1] Due to parent sources, all numerical values pertain only to trees 12 inches dbh and greater. Basal area per acre was calculated by multiplying trees-per-acre values (4th column) by basal area (in square feet) of a tree with diameter shown in Average Tree Diameter (5th column). SDI (Stand Density Index) (Reineke 1933) is calculated by using Trees per Acre and Average Tree Diameter columns.

Sources/Notes: Adapted from Table V in Bright (1914). Austin and Whitney plots were likely established in same general area as an Austin-Whitney tract described in figure 22 later in this white paper; Palmer Junction plots were likely established in same general area as a Lookingglass Creek tract described in figure 22. Note that figure 22 provides similar tree density information as is presented here, although it includes tree density for trees greater than 1 inch in diameter (rather than the 12-inch limit used here), and it provides summary calculations for trees greater than 21 inches in diameter.

4. INFLUENCE OF FIRE EXCLUSION

On dry-forest sites, fire's influence was perhaps as important as sunlight and rain. An historical fire regime of frequent, low-severity surface fires maintained a pattern of large, widely spaced, fire-tolerant trees (fig. 5). These savanna forests supported trees with low flammability traits, and this contributed to ecosystem persistence (Bond and Midgley 1995).

For dry sites, dramatic reductions in fire frequency allowed tree seedlings and saplings, particularly of fire-sensitive species, to persist in biophysical settings where most of them would have been eliminated by the historical fire regime (Agee 1996b, 1998; Cooper 1960; Munger 1917; Mutch et al. 1993; Sloan 1998b; White 1985; Wright and Agee 2004).

Fires in California's presettlement ponderosa pine type, for example, occurred on a frequency of about every 8 years between 1685 and 1889 (Show and Kotok 1924). In eastern Oregon, Keen (1937) sampled a 670-year-old ponderosa pine tree with 25 fire scars dating from 1481 to mid-1930s, and it might very well have experienced more fires than that because not every fire creates a scar (Agee 1993).

Fire-dependent ponderosa pine forest ('park-like pine') was not unique to Blue Mountains or eastern Oregon; it was present in almost every forested region of the western United States, including California (Cooper 1906, Laudenslayer et al. 1989, Show and Kotok 1924), western Montana (Gruell et al. 1982, Habeck 1990), central Idaho (Brock and Brock 1993), Colorado's Front Range (Marr 1967, Veblen and Lorenz 1991, Vestal 1917), and Arizona and New Mexico (Avery et al. 1976, Cooper 1960, Pearson 1923, Woolsey 1911).

Perhaps the most important reason for alteration and loss of park-like ponderosa pine forest has been exclusion of frequent wildfire, whose historical influence was so pervasive that if Rebecca Ketcham, Henry Gannett, Thornton Munger, and George Bright could view the western yellow pine forests of today, they would hardly fail to notice the impact of fire exclusion on forest composition and structure (this paragraph refers to quoted material from Ketcham, Gannett, Munger, and Bright in section 3 – Historical Context).

If Ketcham, Gannett, Munger, or Bright could return to the interior Pacific Northwest today, they would not recognize existing forest conditions, particularly for dry-forest sites. Gone are many of the big yellow pines, some of which were harvested to make moldings, window sashes, and doors, as well as crates for apples and other fruit crops (Bolsinger and Berger 1975, Gedney 1963). Other old-growth ponderosa pines succumbed to outbreaks of western pine beetle, beginning in early- to mid-1930s (Cowlin et al. 1942, Weidman and Silcox 1936).

As ecologically benign fires crept through dry-site forests every 5 to 20 years, they eliminated brush and small trees in their wake (Everett et al. 2000, Franklin and Dyrness 1973, Hall 1976, Wright and Agee 2004). Historical fire ignitions probably came from a combination of lightning and human sources (Boyd 1999, Morris 1934). Fire intervals of less than 5 years are uncommon for the Blue Mountains (Heyerdahl 1997, Maruoka 1994, Hall 1976), suggesting that once a fire occurred, several years of fuel accumulation were required before the same area could burn again (Wright and Agee 2004).

Archaeological evidence suggests that humans inhabited interior Columbia River basin ecosystems for at least 15,000 years (Knudson 1980). It is generally assumed that when Europeans arrived in the New World, American Indians sparsely occupied the land, impacts of native peoples were relatively minor, and landscapes were pristine (Cronon 1996, Kay and Simmons 2002). Subsequent work shows this assumption to be incorrect, as described here by ecologist Daniel Botkin:

> "It often seems that the common impression about the American West is that, before the arrival of people of European descent, Native Americans had essentially no effect on the land, the wildlife, or the ecosystems, except that they harvested trivial amounts that did not affect the 'natural' abundances of plants and animals. But Native Americans had three powerful technologies: fire, the ability to work wood into useful objects, and the bow and arrow.
>
> To claim that people with these technologies did not or could not create major changes in natural ecosystems can be taken as Western civilization's ignorance, chauvinism, and old prejudice against primitivism – the noble but dumb savage. There is ample evidence that Native Americans greatly changed the character of the landscape with fire, and that they had major effects on the abundances of some wildlife species through their hunting" (Botkin 1995).

It is entirely possible that Blue Mountain forests were more primeval at time of Euro-American settlement than before that era. When Columbus landed in 1492, it is estimated that North America (exclusive of Mexico and central America) supported at least 3.8 million Native Americans. By 1800, their numbers had been reduced to a million or less by measles, smallpox, cholera, influenza, and other European diseases (Denevan 1992, Mann 2006, Scott 1928).

Even though their populations were already declining dramatically due to diseases introduced after European contact (Cook 1955), Native Americans of interior Pacific Northwest may have expanded their use of fire in early 1700s, most likely to promote forage for horses they just acquired for the first time (Habeck 1987; Haines 1938; Humphrey 1943; Mosgrove 1980; Stewart 1951, 2009).

Recent investigations indicate that American Indians were far from passive hunters and gatherers often depicted in western movies and novels. Their actions had a profound influence on structure and composition of western ecosystems, a not unexpected result when considering they used hundreds of plants and animals for food, fiber, shelter, forage, and medicine. Fire was often their main tool for creating and maintaining habitats required by 'first foods' plants and animals (Boyd 1999, Denevan 1992, Kay 1994, Quaempts et al. 2018, Robbins 1997, Shinn 1980, Swetnam 1984, Williams 2000).

Because ecosystems with native peoples differ markedly from those lacking an aboriginal influence, a hands-off approach by today's managers will not duplicate conditions under which presettlement ecosystems developed (Botkin 1995, Boyd 1999, Christensen et al. 1996, MacCleery 1992, Stevens 1990, Vale 2002).

But, it is equally as important to acknowledge that technologies used by Native Americans to manage landscapes for thousands of years were far different than those employed by Euro-Americans (Aplet and Keeton 1999, Cronon 1996).

4.1 Plant Succession On Dry Sites

Suppressing underburns had an unintended consequence of allowing open stands of park-like ponderosa pine to be transformed into dense, thick forests of grand fir and Douglas-fir (Harrod et al. 1999, Mast et al. 1999, Sloan 1998b, Turner and Krannitz 2001) (fig. 6). Fire suppression also transformed the structure of dry forests by shifting much of the canopy leaf area from an overstory layer to one or more understory layers.

Ironically, many of these thick, multi-layered, dry forests may present a more attractive appearance than the park-like pine stands they replaced – there seems to be an intuitive human sense that when it comes to forests, lush is better (Gruell 2001, Hjerpe et al. 2016, Scott 1998a).

Tree species that invaded park-like pine forest – grand fir and Douglas-fir – have thin bark, low-hanging branches, highly flammable foliage, and other characteristics rendering them vulnerable to fire damage, particularly when they are small (table 3). With thick bark and few branches close to the ground, ponderosa pine and western larch easily resist surface fires that eliminated firs and other invading tree species (Agee 1994, Cooper 1960, Dickman 1978, Weaver 1967b, White 1985).

When considering climate only (precipitation and temperature), Douglas-fir or grand fir are most assuredly climax species for dry, mixed-conifer sites of the Blue Mountains (dry mixed-conifer forests include ponderosa pine, grand fir, and Douglas-fir potential vegetation types; see appendix 1).

But when surface fire is superimposed on the climatic regime, it results in a marked change in vegetation composition because ponderosa pine, western larch, and other fire-adapted species are then put at a distinct advantage (Habeck 1976, Hall 1976).

Light-water tradeoff theory (Smith and Huston 1989) maintains that plants cannot be optimally adapted to both light and water. Dry forests are water limited, with dominant conifers evolved to compete for water primarily, and sunlight secondarily.

A surface fire regime creates an open stand of fire-resistant species. As long as fires continue, stands are thinned and competition for water is reduced.

In a plant succession context, dry-forest sites where surface fire favored dominance by ponderosa pine are generally early seral; areas where fire exclusion promoted establishment of grand fir and Douglas-fir are late seral (table 4). A pine-dominated early-seral condition is now rare, whereas fir-dominated late-seral stands are currently abundant (Arno and Allison-Bunnell 2002, Caraher et al. 1992, Habeck 1976, Hessburg et al. 1999b, Lehmkuhl et al. 1994).

Although late-seral grand firs and Douglas-firs can establish under ponderosa pine when underburning is absent, they may not have enough resilience to make it over the long run, let alone survive the next drought. This means that many late-seral stands of grand fir and Douglas-fir, which replaced an original stand of early-seral ponderosa pine, are destined to become weak – and weak forests are susceptible to insect, disease, and fire outbreaks (fig. 7; Agee 1996b, Covington et al. 1994, Filip et al. 1996, Filip and Schmitt 1990, Hessburg et al. 1994, Mutch et al. 1993, Oliver et al. 1994a, Powell 1994, Wickman 1992).

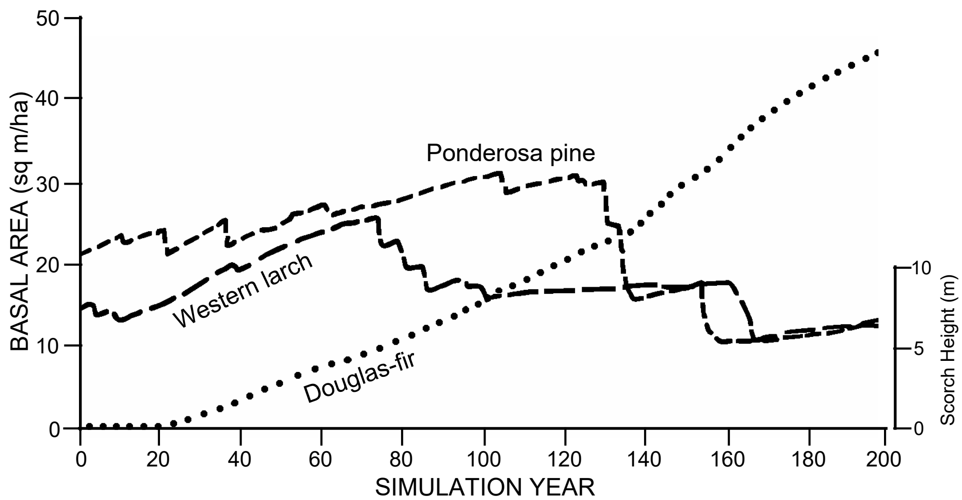


Figure 6 – Forest succession for Douglas-fir/mallow ninebark (PSME/PHMA) plant association in an absence of recurring wildfire (adapted from Keane et al. 1990). In this simulation study, "compositional shifts from ponderosa pine and larch to Douglas-fir occurred in simulations of 50-yr fire intervals and with fire suppression. The simulated scenario of fire suppression (shown above) resulted in development of dense stands of relatively small trees. Such stands are susceptible to insect and disease infestations. They are also vulnerable to severe damage by wildfires because of heavy accumulations of dead fuels, and continuity of ladder and overstory fuels" (Keane et al. 1990).

This study also demonstrates that fire intervals of 20 years or less result in Douglas-fir being essentially absent from dry-forest landscapes due to its high fire vulnerability as a seedling or sapling (Agee 1996b). Since dry-forest surface fire occurred in Blue Mountains on a cycle of 5-20 years (Hall 1976, 1980), this study helps explain why species composition has changed dramatically for this biophysical environment. This and other studies show that fire exclusion in dry-forest types results in greater canopy cover and density of shade-tolerant trees, higher fuel loads, and increased fuel continuity, which combine to increase potential for high-severity, stand-replacing fires (Agee and Skinner 2005, Parsons and DeBenedetti 1979, North et al. 2005, Zald et al. 2008).

Table 3: Fire resistance characteristics for common conifers of dry-forest sites.

Tree Species	Bark Thickness	Rooting Habit	Bark Resin (Old Bark)	Branching Habit	Stand Density	Foliage Flammability	Overall Resistance
Ponderosa pine	Very thick	Deep	Abundant	Moderately high & open	Open	Medium	High
Douglas-fir	Very thick	Deep	Moderate	Moderately low & dense	Moderate to dense	High	High
Western larch	Very thick	Deep	Very little	High and very open	Open	Low	Very high
Grand fir	Thick	Shallow	Very little	Low and dense	Dense	High	Medium

Sources/Notes: Adapted from Flint (1925) and Starker (1934). Species rankings reflect a predominant situation for each trait. Tree species generally achieve fire tolerance by developing thick bark to protect their cambium, and by self-pruning to raise their lower crown above average flame height in the event of a fire. Species traits vary during a lifespan of an individual tree, and from one individual to another in a population. For example, grand fir's bark is thin when young, but relatively thick when mature.

Table 4: Comparison of fire return interval and tree longevity, in years.

PVG	Fire Return Interval	Seral Stage	Predominant Tree Species	Tree Longevity (Years) Typical	Maximum
Dry Forest	15 Years	Early	Ponderosa pine	300	725
		Mid	Douglas-fir	200	500
		Late	Grand fir	200	400
Moist Forest	30-50 Years	Early	Western larch	300	915
		Mid	Western white pine	400	615
		Late	Grand fir	200	400
Cold Forest	80-110 Years	Early	Lodgepole pine	100	300
		Mid	Engelmann spruce	250	550
		Late	Subalpine fir	150	250

Sources/Notes: PVG (potential vegetation group) is described in Powell et al. (2007). Fire Return Interval is from Agee (1993; table 1.2, page 13). Seral Stage refers to a particular phase in the sequence of plant communities occurring after a disturbance event; seral communities are classified as early-, mid-, or late-seral depending on the successional role of their species composition (Hall et al. 1995). Predominant Tree Species shows a predominant species associated with each seral stage by PVG. Tree Longevity age values are from Powell (2000).

Successional roles of ponderosa pine and white (grand) fir were recognized by early silvicultural researchers, as demonstrated by these comments about forest succession and development for Sierra Nevada Mountains of central California (Dunning 1923):

> "Where natural conditions of site favor white fir, this species is destined to succeed yellow pine unless the normal succession is disturbed by fire or other accidents. Fir seeds germinate more abundantly than pine under stands of yellow pine, whose litter and shade exclude their own seedlings, and the young [fir] trees endure suppression longer. Moreover, height growth of fir is more rapid, and the total height attained is greater than for yellow pine. In the past occasional fires have been primarily responsible for sustaining yellow pine on fir sites.
>
> Fir seedlings and young trees are far more susceptible to fire damage than the pine because of their thinner bark with balsam cysts, more inflammable foliage, and small resinous terminal buds which are far less resistant than those of yellow pine. The fir is more often eliminated by fungi entering through fire scars than is pine. Exposure of mineral soil and openings created by fire favor yellow pine."

Early-seral communities developing under an influence of recurring disturbance can be ecologically resilient. A disturbance regime for these dry-forest sites was generally dominated by frequent, low-severity fire, resulting in open, multi-aged stands with a vigorous herbaceous undergrowth.

Disturbance frequency determines the length of successional cycles for a particular ecological system. Ecosystems with frequent disturbance have continually interrupted successions and exhibit a relatively narrow range of plant communities and vegetation structure (Steele and Geier-Hayes 1995). A good example of a forest ecosystem maintained by frequent disturbance is presettlement, park-like ponderosa pine forest (see fig. 5, and fig. 34 later in this paper).

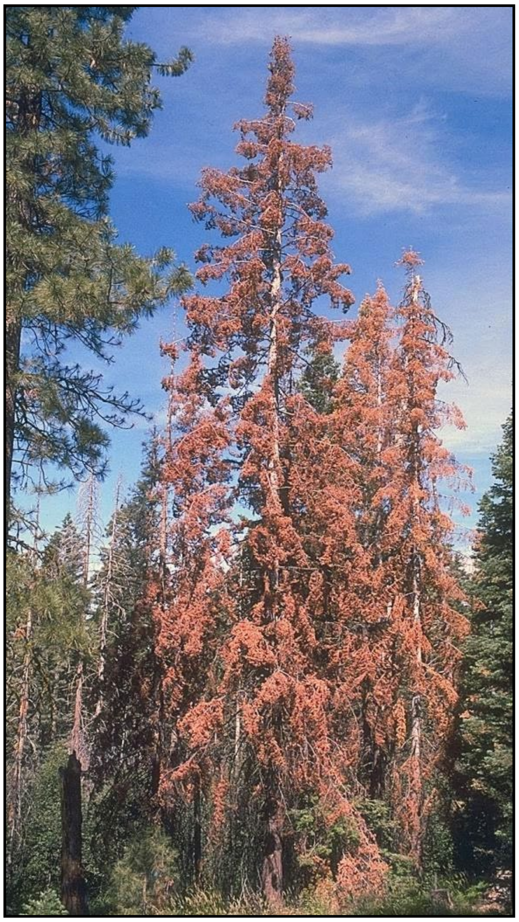


Figure 7 – Grand fir trees killed by fir engraver bark beetles (from Powell 1994). Defoliation, drought, root disease, dwarf mistletoe, overstocking, and other stressors increase a tree's susceptibility to bark beetle attack (Filip 1994, Filip and Schmitt 1990). Fir engraver and Douglas-fir beetles caused widespread damage in the Blue Mountains during late 1980s and early 1990s. On dry-forest sites, bark beetles and other insects focus their attention on water-stressed and low-vigor trees (Schowalter and Withgott 2001). High-vigor trees are better able to ward off insect and disease attacks by producing phenols, terpenes, resins, and other defensive chemicals (Christiansen et al. 1987, Waring 1987). Thinning, a silvicultural practice, is used to release overcrowded trees from effects of competition and improve their physiological condition and vigor (Oliver and Larson 1996). In the Blue Mountains, high stand density is known to favor at least eight forest insects and seven forest diseases or parasites, primarily because overstocking contributes to low tree vigor, and low vigor translates into reduced insect and disease resistance (Kolb et al. 1998, Langenheim 1990, Mitchell et al. 1983, Nebeker et al. 1995, Phillips and Croteau 1999, Pitman et al. 1982, Safranyik et al. 1998).

Presettlement forests typically consisted of large trees with an open to moderately dense canopy, an understory featuring vigorous shrubs and herbs, and small patches of young trees (figs. 5 and 34). "Light and water could penetrate the forest canopy to nurture and maintain a healthy understory. The observation that more wildlife species are adapted to large-tree, open canopy forest than to any other combination of tree size and canopy closure suggests that open conditions were common" historically (Gruell 2001).

Plant succession. A process by which a series of different plant communities, and their associated animals and microbes, successively occupy and replace each other over time in a particular ecosystem or landscape location following a disturbance event (Kimmins 1997). A process of development (or redevelopment) of an ecosystem over time (Botkin 1990).

Surface fire. A fire burning primarily along the ground, consuming leaf litter (needles), grass, forbs, shrubs, short trees, fallen branches, and other fuels located on, or directly adjacent to, the forest floor (Scott and Reinhardt 2001). Surface fire tends to cause minimal damage to larger trees; historically, this was a prevailing fire type for ponderosa pine ecosystems throughout the western United States.

4.2 Fire's Influence On Site Nutrition

After frequent fires were suppressed following Euro-American settlement, microbial decomposition has been unable to process rapidly accumulating organic debris (needles, twigs, and branches) on dry sites. Impaired decomposition and nutrient cycling rates can be initial signs of stress in dry-forest ecosystems (Bormann and Likens 1979). High organic matter levels on dry sites, with nutrients held in forms unavailable for plant growth, indicate that decomposition and nutrient cycling processes are not functioning properly (Yazvenko and Rapport 1997).

Numerous studies have documented slow decomposition rates for woody biomass of the western United States. This means that interior Pacific Northwest forests may have depended more on nitrogen-fixing plants and surface fire to cycle nutrients than on microbial decomposition of woody debris (Harvey 1994, Harvey et al. 1994) (fig. 8).

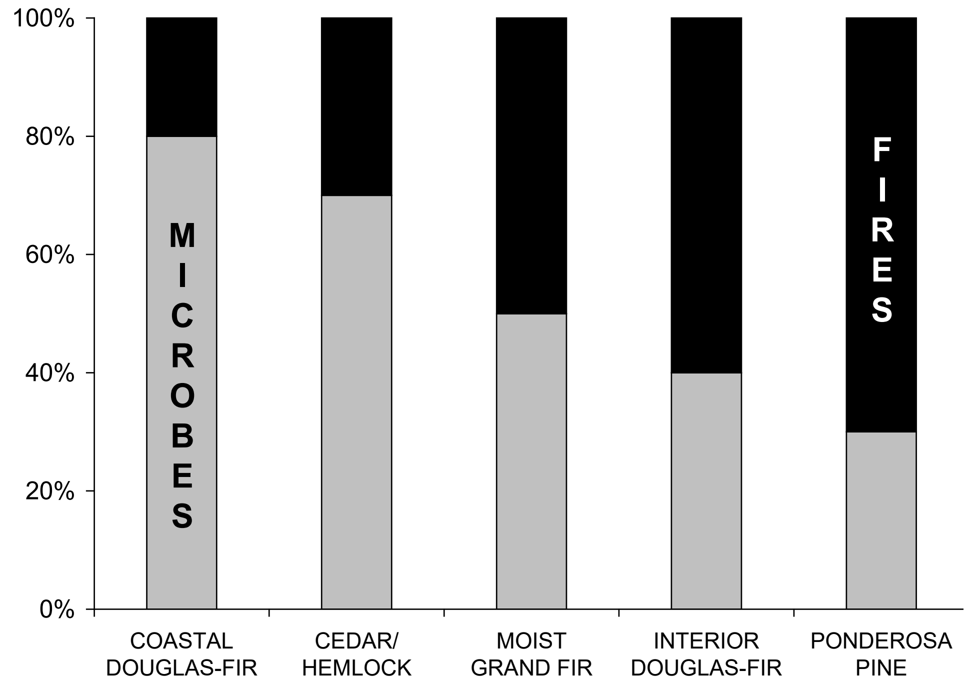


Figure 8 – Microbes and fire as agents of decomposition (adapted from Harvey et al. 1994). Fire (black portion of bars) and microbes (gray portion) are important decomposition and nutrient cycling agents. For a dry-forest climatic zone of the interior Pacific Northwest (interior Douglas-fir and ponderosa pine forest types above), a short-interval fire regime (surface fires) was a primary cycling process because microbial decomposition is too slow to keep pace with biomass accumulation on these sites. Microbial decomposition is limited for cold or dry environments, allowing biomass to accumulate.

And, these two nutrient-cycling processes – microbes and fire – are obviously related because frequent fire not only converts litter to its mineral elements (calcium, etc.), but it also functions to periodically rejuvenate snowbrush ceanothus, lupines, peavines, American vetch, russet buffaloberry, and other nitrogen-fixing plants (Hendrickson and Burgess 1989, Newland and DeLuca 2000).

Having nutrients tied up in pine litter, which decomposes more slowly than grass litter in a summer-dry Mediterranean climate of the interior Pacific Northwest (Hart et al. 1992), means that nutrient cycling has undoubtedly deteriorated for contemporary forests when compared with historical conditions (Cooper 1960; Covington and Moore 1994a, 1994b; Weaver 1943).

This trend also means that dry mixed-conifer forests are accumulating biomass faster than it is being removed by surface fire, timber harvest, or microbial decomposition, leaving millions of acres vulnerable to drought stress, insects and diseases, and uncharacteristic wildfire (Sampson and Adams 1994). [But this trend may change as wildfire increases by orders of magnitude, potentially removing substantially more biomass – see figure 40 later in this white paper.]

Interactions Between Fire And Nutrients

Providing adequate levels of site nutrition is important for maintaining tree resistance to insects and diseases (Mandzak and Moore 1994). In central Oregon, for example, Reaves and others (1984, 1990) found that ash leachates (e.g., chemical compounds produced when water percolates through the ash produced by a fire) from prescribed burns in ponderosa pine forests has a negative effect on the growth of *Armillaria ostoyae*, cause of Armillaria root disease. These studies found that much of the Armillaria suppression is related to a fungus called *Trichoderma* – a strongly antagonistic competitor of Armillaria root disease – and *Trichoderma* apparently benefits from ash leachates (Filip and Yang-Erve 1997; Reaves et al. 1984, 1990).

On low-productivity sites (generally dry areas with coarse or shallow soils, and thin forest floors), broadcast burning can be detrimental from a nutritional standpoint. Short-term benefits of prescribed fire may be offset by high soil pH, nitrogen and sulfur deficiencies, and other nutritional problems later in a forest's life (Brockley et al. 1992, DeBell and Ralston 1970, Mandzak and Moore 1994, Tiedemann 1987).

In central Oregon, prescribed fire was observed to cause a net decline in nitrogen mineralization rates and long-term productivity (Cochran and Hopkins 1991, Monleon et al. 1997). But a reduction in site productivity following prescribed fire might not be solely due to nutrient cycling issues – up to 40 percent of a tree's annual net production on low-productivity sites is used to produce fine roots (Keyes and Grier 1981), and because these roots are located near the soil surface, they can be damaged or killed by prescribed fire, particularly when fire is applied in spring. In a study involving ponderosa pine on the Wenatchee National Forest in eastern Washington, wood increment was suppressed on spring-burned areas for at least 8 years after treatment, and much of this growth reduction was attributed to fine-root damage (Grier 1989).

Forest floor also plays an important role in an ecological process called allelopathy (Rose et al. 1983, Tinnin and Kirkpatrick 1985, Wardle et al. 1998). Allelopathy refers to a competitive strategy in which some plant species produce chemical compounds interfering with the germination, growth, or development of competing plants. Chemicals produced during allelopathy are often referred to as phytotoxins (Kelsey and Harrington 1979, Rietveld 1975).

If phytotoxins are produced by a climax tree species, such as ponderosa pine on dry-forest sites where moisture is too limiting and growing-season temperatures are too extreme to allow establishment of Douglas-fir or grand fir, then any phytotoxins would obviously affect its own offspring. In situations where a dominant plant species produces chemicals limiting its own abundance, a phytotoxin is referred to as an autotoxin (e.g., a 'self-toxin').

If ponderosa pine produces an autotoxic chemical on sites where it is the climax tree species, and this hypothesis has not been definitively proven to my knowledge, then it could confer survival value to the species. When moisture is limiting, as it so often is for dry-forest sites, and when growth-inhibiting conditions occur in an ecosystem where short-interval surface fire was a prevailing disturbance process, then adequate tree survival and growth can only be maintained at relatively low tree densities. Therefore, chemicals from mature trees could function as 'density regulators' by reducing germination and growth of its own progeny (Kelsey and Harrington 1979).

Does Allelopathy Help Regulate Seedling Density?

Trees with capability to use allelopathy (e.g., autotoxic chemicals) to regulate seedling density could possess an important evolutionary adaptation because this trait could effectively limit or prevent overcrowding, stagnation, and competition between individuals of the same species. This life-history trait would ensure that some small proportion of a seedling cohort would grow fast enough to reach a size conferring reasonable resistance to a frequent surface fire regime operating on dry-forest sites (Biswell 1973, Cooper 1960, White 1985).

Fred Hall, a Forest Service ecologist, speculated that a selective inhibitory substance is present in ponderosa pine litter, and that it is destroyed by periodic underburning (Hall 1991). Without fire, this substance could accumulate in the upper mineral soil (or in the organic horizons?) and reduce ponderosa pine establishment and growth. And we already know that leachate from pine litter and pinegrass leaves has been shown to retard root growth of germinating ponderosa pine seeds (Eckert 1975, Jameson 1968, Kelsey and Harrington 1979, McConnell and Smith 1971, Rietveld 1975), perhaps corroborating Hall's suspicion. But when considering the impact of pathogenic fungi located in the forest floor's organic horizons (Daniel and Schmidt 1972), I wonder if Fred's 'selective inhibitory substance' might have involved pathogenic fungi, allelopathic phytotoxins, or perhaps some combination of both?

It is clear that when plant succession occurs on dry-forest sites in the absence of recurring wildfire, it eventually results in reduced availability of mineral nitrogen and causes increased accumulation of polyphenolic compounds in the mineral soil (MacKenzie et al. 2006, Souto et al. 2000, Wardle et al. 2000). And these changes caused by fire suppression are superimposed on high levels of natural soil variation related to vegetation influences – in a study from the southwest, 69% of soils in openings between patches were Mollisols (a grassland soil) whereas 75% of soils in presettlement tree patches were Alfisols (a forest soil) (Abella et al. 2013).

4.3 Awareness Of Changes Caused By Fire Suppression

If fire exclusion caused major changes in ecosystem components (e.g., species composition, forest structure, and tree density) on dry-forest sites, then why weren't they recognized sooner? Actually, many of these changes were recognized early on, but they did not generate a response because of prevailing attitudes of the time.

Two studies described earlier illustrate differing attitudes about fire's role in ponderosa pine forests. Gannett (1902) surveyed federal forests before they were viewed as a source of commodities; he found many trees with fire scars (fig. 9) but fire had not done "them any serious damage." Munger (1917) found few stands without some sign of fire's influence, and yet fire was a scourge causing an "enormous amount of damage to yellow-pine forests."

Figure 9 – Many ponderosa pine trees have basal scars caused by recurrent surface fire, a pervasive disturbance process before wildfire exclusion efforts began around 1900 (image acquired by D.C. Powell on the North Fork John Day Ranger District, Umatilla National Forest, in October 2009). Species like ponderosa pine achieve fire tolerance by developing thick bark to protect their cambium, and by self-pruning their lower crown to raise crown base height above average flame length in event of a fire. "Both of these characteristics are size dependent; thick bark is a relative characteristic with individuals of larger diameter having thicker bark, and crown height is dependent on the height of individuals" (Roberts and Betz 1999). This quote helps us remember that fire tolerance is primarily a species-specific life history trait (see table 3), but it also varies with size of individuals in a population.

Munger's (1917) comments about fire-caused damage reflect a commodity paradigm of his era; ponderosa pine forests were to be managed as a sustainable source of wood products, and fire was perceived as an obstacle to reaching that goal. William Greeley, an early Chief of USDA Forest Service, expressed a commodity philosophy in this way (Greeley 1912):

> "To the extent to which the over-ripe timber on the National Forests cannot be cut and used while still merchantable, public property is wasted. This is the very antithesis of conservation."

Munger's commodity orientation was shared by other Forest Service researchers working in western United States, as demonstrated by a passage from *The Role of Fire in the California Pine Forests* (Show and Kotok 1924).

> "Physical conditions in the pine forests of California have led to the frequent recurrence of fires for centuries, but the fact that magnificent forests still cover large areas and give the appearance of well-stocked, vigorous stands has blinded the public to the harm that fires have done and are steadily working throughout the whole region.
>
> Were it possible for the observer to visualize the entire area on which pine has grown, and to behold it truly fully stocked, he would then see by comparison that the present California pine forests represent broken, patchy, understocked stands, worn down by the attrition of repeated light fires."

Land managers working for the early USDA Forest Service also recognized that fire-caused changes were occurring on the landscape, as described in these three accounts:

> "There are patches of 'scabland,' characterized by very shallow soil, many rock fragments and a total absence of vegetation except in the spring months. It is interesting to note that some of these areas are being occupied by sagebrush where a few years ago, there was none. A possible explanation is that the annual fires of the Indians kept it killed out and now it has a chance to develop.
>
> Yellow pine is slowly encroaching upon the sagebrush; the chief factor in its rate of advance being moisture, provided fire is kept out. The same statement will hold true in regard to the other open areas as well. As fast as the reproduction has pushed out from under the protection of the parent trees, the periodical fires have killed it back, thus keeping the timberline practically stationary" (Evans 1912).
>
> "Throughout the conifer type there is ample reproduction to more than replace the present stand of timber. The major part of the reproduction has come in since the forest has been protected against fires. Several areas were noticed where the yellow pine seedlings were so thick that it was almost impossible to ride through them. Practically all of the stockmen were complaining that the reproduction is coming in so thick on their allotments that it is greatly decreasing the carrying capacity of the range" (Aldous 1914).
>
> "In times gone by the frequent fires killed out the patches of reproduction about as soon as they occurred, but since the fires have been in large measure stopped, reproduction has come in very thickly in most Yellow pine forests, and its abundance points to a heavier future stand than the existing stand. This abundance is decidedly out of proportion to the comparatively small number of old trees in most Yellow pine forests which make up the present stand" (Bright 1914).

When evaluated in a context of resulting changes to ecosystem composition and structure, fire exclusion was probably not an appropriate policy. The problem was not necessarily fire exclusion per se – it was the fact that surrogates were not substituted for fire, fire surrogates providing similar ecosystem functions such as nutrient cycling, fuel reduction, and tree thinning.

"In the absence of fire, vegetation development generally increases ladder and canopy fuels as tree stands become denser (Hessburg et al. 2000), and more surface fuels accumulate as the vegetation shifts from herbaceous plants and shrubs to woody material (Pinol et al. 2005)" (Stephens et al. 2014).

Harold Weaver's Observations About Fire Protection

More than 60 years ago, an early fire ecologist (Harold Weaver) made insightful observations about fire exclusion and its impact (Weaver 1943). Many of his comments have obvious relevance to our contemporary situation featuring uncharacteristic fire behavior in dry mixed-conifer forests, caused primarily by unusually high fuel accumulations (Arno and Allison-Bunnell 2002, Carle 2002, GAO 1999, Hessburg et al. 2005, Kenworthy 1992, Pyne 1997).

Here are Harold Weaver's observations:

"It is obvious that the present policy of attempting complete protection of ponderosa pine stands from fire raises several very important problems. How, for instance, will the composition of the reproduction be controlled? If ponderosa pine is desired on vast areas how, unless fire is employed, can other species such as white fir be prevented from monopolizing the ground? On the other hand, if it is decided to permit such species as white fir to come in under mature ponderosa pine, how much of the public's money are foresters justified in spending in trying to keep fire out? Even with unlimited funds, personnel, and equipment, can they give reasonable assurance that they can continue to keep such extremely hazardous stands from burning up? If they feel reasonably sure of this, can they then give assurance that the timber products of such stands will be more valuable than those that might otherwise be derived from ponderosa pine and will in addition justify the high protection costs?"

4.4 Summary: Changes Caused By Fire Exclusion

Contemporary dry-forest landscapes reflect many long-term influences of fire exclusion:

1. Without frequent fire to retard plant succession, fire-sensitive grand fir and Douglas-fir invaded sites where ponderosa pine had been maintained as a fire disclimax (Lunan and Habeck 1973; Parsons and DeBenedetti 1979; Sloan 1998b; Stephens et al. 2016, 2018).
2. Deep layers of organic matter accumulated under thickening conifer forests, tying up nitrogen and other nutrients that are cycled slowly without fire (Harvey 1994).
3. Fire exclusion removed an important tree thinning agent, causing tree density to accumulate and eventually contributing to a wide variety of density-related changes:
   a. Bark beetle outbreaks occurred frequently in overstocked, second-growth ponderosa pine forests (Keen 1950, Miller 1926, Sartwell 1971).
   b. Small trees killed by suppression (density-dependent mortality) were usually the shade-intolerant species succumbing quickly to intertree competition (fig. 10).
   c. High stand density created elk thermal cover that is neither appropriate nor sustainable in an ecological context (Powell 2012).
   d. Dense forests produce less water for streams and springs than open forests (Bosch and Hewlett 1982, Covington and Moore 1994b, Grant et al. 2013, Troendle 1983).
4. Light surface fires facilitated ponderosa pine regeneration by exposing some mineral soil, and by temporarily reducing competition from grasses and sedges (Hall 1976).
5. Surface fires raised 'height to live crown base' by pruning lower branches of overstory trees, reducing potential for crown-fire initiation (Agee 1996c, Keyes 1996).
6. By maintaining open stands and allowing perennial herbs to persist, surface fire provided forage for both livestock and wildlife (Hedrick et al. 1968, Irwin et al. 1994).
7. Fire supported nutrient cycling by rejuvenating snowbrush ceanothus, lupines, peavines, vetch, buffaloberry, and other nitrogen-fixing plants (Newland and DeLuca 2000).
8. Frequent fires maintained low fuel accumulations and low crown-fire susceptibility in areas with dry summers, high winds, and abundant lightning (Dodge 1972, Hall 1976).
9. Fire smoke limits germination of dwarf-mistletoe seeds (Zimmerman and Laven 1987), so fire exclusion probably contributed to worsening dwarf-mistletoe problems.

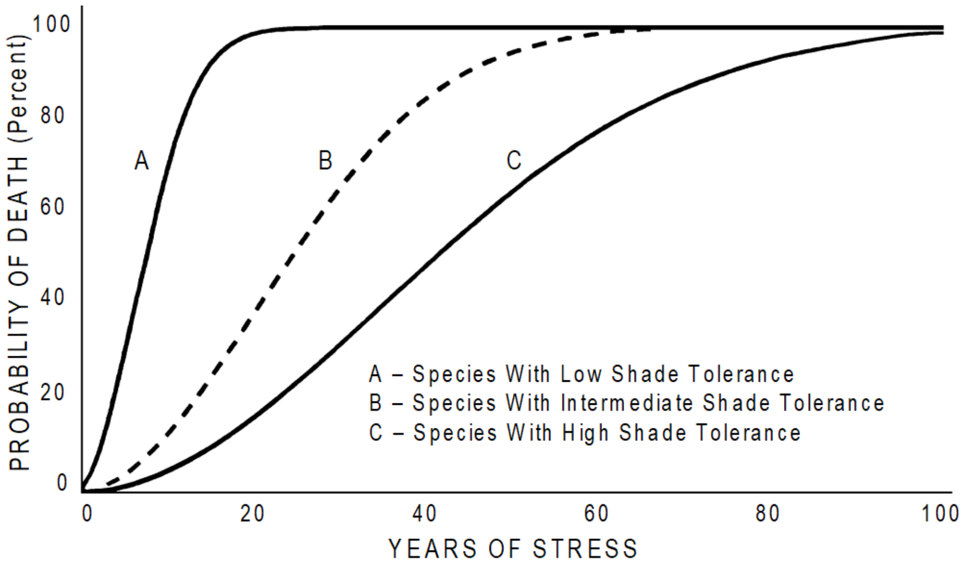


Figure 10 – Tree resistance to stress varies with shade tolerance (adapted from Keane et al. 1996). Intolerant tree species (lodgepole pine, ponderosa pine, western larch) die relatively quickly when exposed to chronic stress such as high stand density. Trees with intermediate tolerance (Douglas-fir and western white pine) can withstand a longer period of stress without dying. Shade tolerant species (Engelmann spruce, grand fir, subalpine fir) can endure relatively long periods of stress before experiencing mortality.

10. Fire exclusion allowed certain fire-sensitive shrubs (bitterbrush, sagebrush) to invade dry-forest undergrowth plant communities (Burkhardt and Tisdale 1976, Gedney et al. 1999).
11. Western juniper increased with fire exclusion (fig. 11) (Gedney et al. 1999), reducing water yields because juniper uses more water than grasses and shrubs (Miller et al. 1987).
12. Loss of an open park-like structure had negative impacts on blue grouse (Pelren and Crawford 1999) and white-headed woodpecker (Buchanan et al. 2003, Casey et al. Undated).
13. Tree mortality caused by density-responsive insects and diseases increased, particularly from bark beetles and defoliators (Anderson et al. 1987, Hadley and Veblen 1993).
14. Fire-sensitive conifers displaced fruit-bearing shrubs, deciduous trees, and herbaceous plants – important food sources for wildlife (Bartos and Campbell 1998, Gruell 2001).
15. Native Americans burned the landscape to promote forage for horses, and to maintain important habitat for 'first foods' plant species (Habeck 1987; Haines 1938; Humphrey 1943; Mosgrove 1980; Quaempts et al. 2018, Stewart 1951, 2009).
    [Note: Since responsibility for provision of plant-based 'first foods' tended to reside with women, they often possessed much of a tribe's prescribed-fire expertise, as noted in this account: "On the way, they met an old squaw, with a large firebrand in her hand, with which she had just set the grass and bushes on fire; when surprised, she stood motionless, and appeared to be heedless of anything that was passing around her" (Wilkes 1844).]
16. Fire exclusion created landscapes that are more homogeneous, with fewer vegetation types and lower patch densities (Lehmkuhl et al. 1994, Miller and Urban 2000).
17. Landscape diversity declined after fire was prevented from periodically creating early-seral plant communities (Hessburg et al. 1999b, Taylor and Skinner 1998).

Figure 11 – Western juniper expansion on a dry-forest site, likely as a result of fire exclusion (Kahler planning area, Heppner Ranger District). This image portrays a dry forest example of the ponderosa pine/bitterbrush/Ross' sedge (PIPO/PUTR/CARO) plant association (Johnson and Clausnitzer 1992). Juniper is occasionally associated with late-seral communities in this plant association, but it typically occurs at low canopy coverage (2% mean cover for seven PIPO/PUTR/CARO stands sampled by Johnson and Clausnitzer 1992), and it is not found in every stand (juniper occurred in 42% of the samples). The amount of juniper shown here is greater than what was encountered by Johnson and Clausnitzer (1992, appendix C) in their late-seral sample stands. Juniper has increased in areal extent from historical levels – the interior Columbia Basin ecosystem management project reported increases of 243% for the juniper/sagebrush cover type in the Blue Mountains ecological reporting unit (Quigley and Arbelbide 1997, p. 676). Although much of this reported increase involves juniper expansion into rangelands, juniper also increased on dry-forest sites. Manifold increases in western juniper abundance have been reported in many studies examining eastern Oregon vegetation conditions (Azuma et al. 2005, Gedney et al. 1999, Knapp and Soulé 1998, Miller et al. 2005).

4.5 Active Management Implications Of Fire Exclusion

Results from many scientific assessments completed over the past four decades concluded that impacts associated with wildfire, insects, and diseases are primarily related to changes in species composition, forest structure, and tree density, all of which were affected to a large degree by fire exclusion.

For dry forests, low-severity surface fire is the keystone ecosystem process, and its exclusion by human society has many consequences – some of which were intended, but many of which were not. In this context, adopting an active management (restoration) approach (see section 7, "Restoration of Dry-Forest Ecosystems") is a reasonable response to an historical paradigm of fire exclusion.

Fire exclusion allowed fire-resistant species (ponderosa pine primarily) to be replaced with fire-sensitive species (Douglas-fir when small, grand fir, and western juniper when small). This change affected both ecosystem resistance and resilience because dry forests cannot resist fire when their composition is dominated by fire-sensitive species, and they cannot sustain their resilience when a high proportion of trees are killed by fire (see fig. 19 later in this white paper), and thin-barked invaders (small Douglas-firs and grand firs, especially) are easily fire-killed.

Appendix 4, *Reducing Representation of Douglas-fir and Grand Fir on Dry-Forest Sites*, provides concepts and rationale for considering timber harvest-related tools for reducing representation of Douglas-fir and grand fir cover types on a dry-forest landscape, or Douglas-fir and grand fir trees within a typical dry-forest stand, when either species is over-represented for dry-forest biophysical environments.

Appendix 4 shows how recently developed restoration tools can be used in a dry-forest project planning context, especially a dry-forest guide (Franklin et al. 2013) and a publication to help determine whether large Douglas-firs (≥ 21" dbh) are old (≥ 150 years at breast height) (Van Pelt 2008).

Tools and a planning rationale described in appendix 4 can help land managers decide if it is appropriate to amend the Eastside Screens Forest Plan standards to remove large, but young, Douglas-firs and grand firs as part of an integrated dry-forest restoration strategy. Removing some proportion of Douglas-fir and grand fir stands, or trees, can address many fire-exclusion consequences on species composition, as discussed in this section 4 of the white paper.

A list in section 4.4 enumerates 17 ecosystem changes relating to fire exclusion on dry-forest sites. Although extensive, it still may not furnish a comprehensive accounting of all fire-exclusion influences – but it does provide an inkling of the vast scope of fire as an ecosystem process, including its effect on dwarf mistletoe seed germination and other life-history functions.

Active management treatments, particularly thinning and prescribed fire, can be implemented as restoration practices, in proper places and at appropriate times, to help recover and then sustain the resilience of crucially important dry-forest ecosystems (section 7 – Restoration of Dry-Forest Ecosystems – provides a detailed restoration discussion).

5. INFLUENCE OF UNGULATE HERBIVORY

Fire exclusion obviously influenced forest structure and composition, particularly for dry sites, but it is not the only factor to have done so. Many studies from western North America indicate that herbivory by wild and domestic ungulates has been as influential as fire exclusion in shaping wildland ecosystems, especially for dry forests (Belsky and Blumenthal 1997, Fleischner 1994, Hatton 1920, Madany and West 1983, Oliver et al. 1994c, Parks et al. 1998, Riggs et al. 2000, Rummell 1951, Steele et al. 1986, Zimmerman and Neuenschwander 1984).

Livestock, primarily cattle and sheep, were initially brought into eastern Oregon and eastern Washington during the 1840s via the Oregon Trail (Irwin et al. 1994, Oliver et al. 1994c). But Native American horse herds were already large and well established by then, having arrived in the Blue Mountains around 1730 after progressively migrating northward from the Santa Fe, New Mexico area (Haines 1938, USDA Soil Conservation Service 1941).

At the time of Euro-American settlement, much of the interior Pacific Northwest was covered with lush grass and other herbaceous vegetation (Galbraith and Anderson 1970, Humphrey 1943, Munger 1917). Forest inspector Harold Langille described rangeland conditions prior to extensive changes caused by heavy livestock grazing (Langille 1906):

> "A few years ago Eastern Oregon was one of the best range sections of the West. The rich bunch grass waved knee deep on hill and plain in such close growth that it was mowed with machines for hay."

During summer and fall of 1861, large numbers of sheep and cattle were driven into eastern Oregon and Washington from the Willamette valley of western Oregon. The winter of 1861-1862, however, was one of the most severe ever recorded for the Pacific Northwest and it almost wiped out this fledgling livestock industry (Galbraith and Anderson 1970, Humphrey 1943).

During the late 19th and early 20th centuries, immense bands of sheep grazed in the Blue Mountains (figs. 12 and 13), causing persistent changes in vegetation composition (Bright 1914, Bright and Powell 2008, Coville 1898, Galbraith and Anderson 1970, Griffiths 1903, Humphrey 1943, Tucker 1940). Sheepherders made an annual migration with their flocks, following the snow from low elevations in the spring to high elevations in the summer, and then back to low elevations during autumn (Darlington 1915, Oliver et al. 1994c).

Sheep grazing caused conflict between cattle ranchers, homesteaders, and sheepherders because sheepherders were often nomadic (in contrast to cattle ranchers and homesteaders who tended to be year-long residents), and because conventional wisdom held that sheep caused rangeland deterioration to a greater extent than cattle (Lomax 1928, Minto 1902, Oliver et al. 1994c).

Forest inspector Harold Langille described the sheep grazing situation well in this account:

> "Sheep from Wasco, Crook, Sherman, Gilliam, Umatilla and Morrow Counties are driven to the mountains early each season and ranged up to the very doors of the actual settlers and cattle owners. There has been some trouble in the past resulting in bloodshed, but nothing as serious as that which threatens to come about in the near future" (Langille 1906).

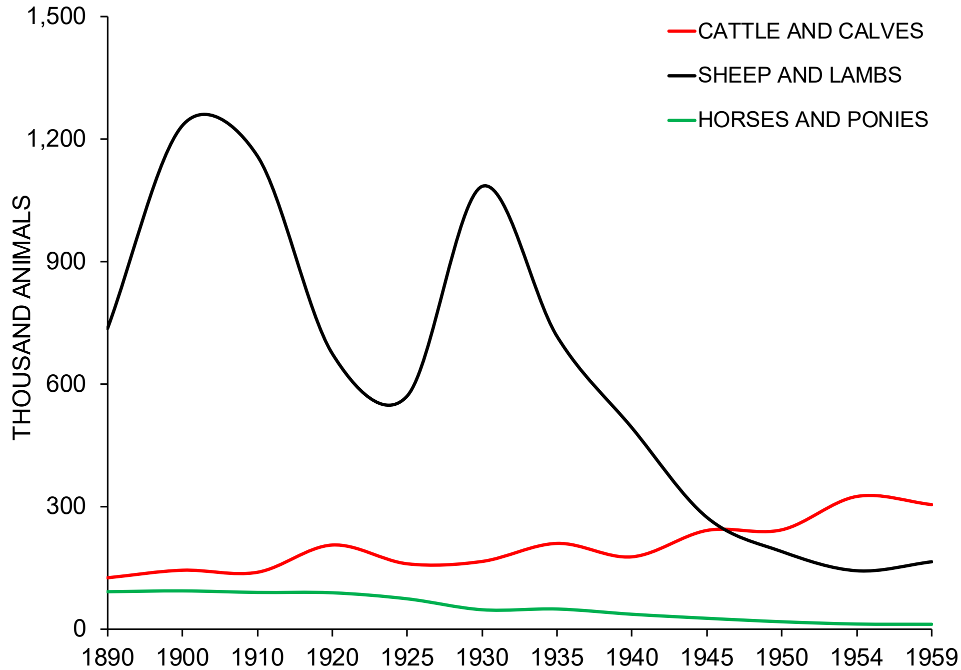


Figure 12 – Number of domestic grazing animals, summarized for three livestock categories, for nine counties in northeastern Oregon and southeastern Washington (Asotin, Columbia and Garfield in Washington; Grant, Morrow, Umatilla, Union, Wallowa and Wheeler in Oregon). Data derived from Bureau of Census agricultural summaries (Bureau of Census 1895, 1902, 1913, 1922, 1927, 1932, 1942, 1946, 1952, 1956, 1961).

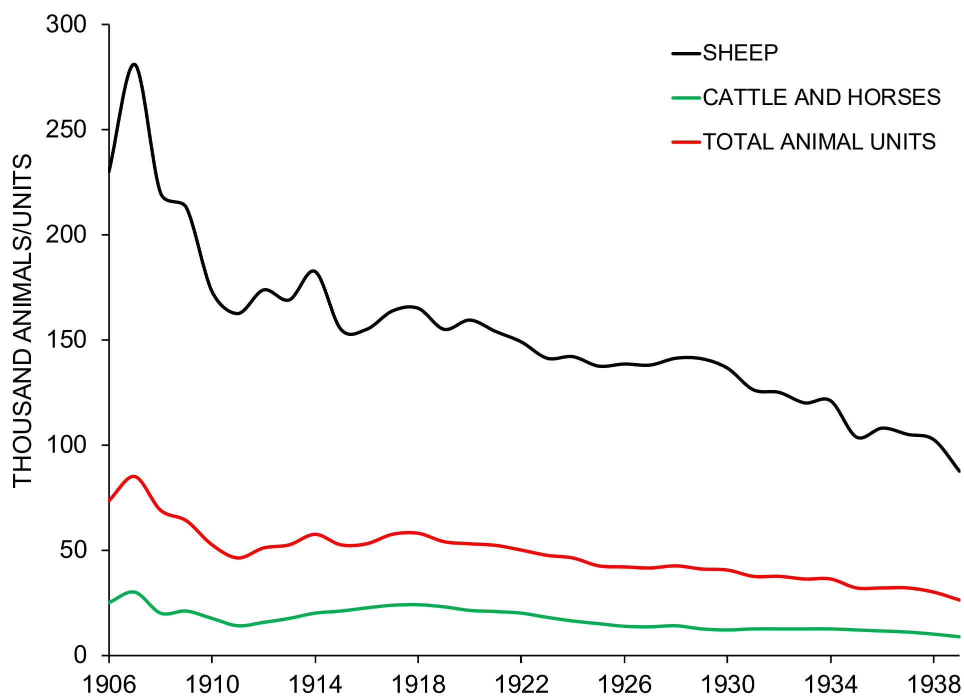


Figure 13 – Grazing summary for Umatilla National Forest, 1906-1939. Data derived from USDA Soil Conservation Service (1941) (note: little information is provided by this source about the basis for calculation of 'Total Animal Units').

An early survey of sheep ranges found moist mountain meadows entirely devoid of vegetation and experiencing severe erosion (fig. 14). A complete collection of herbaceous plants growing in a heavily grazed meadow found not a single perennial species, and no annuals exceeding two inches in height. Sheep browsing had damaged all shrubs other than snowbrush ceanothus (*Ceanothus velutinus*); even small ponderosa pines were fed upon (Griffiths 1903, Langille 1903).

When the Blue Mountains were surveyed early in the twentieth century, overgrazing was deemed to have been severe enough to influence whether forest cover was present or not, as described here by Forest Inspector Harold Langille during an examination of Heppner Forest Reserve (Langille 1903):

> "It was everywhere observed that upon tracts upon which there is no forest cover there is no soil. At one time these areas were covered with soil to a depth of from one to two feet, and sufficient soil binding vegetation grew upon it to resist the destructive elements – wind and water – but persistent overgrazing destroyed this cover, and, there being no tree growth to protect the soil, it rapidly disappeared, leaving nothing but a bed of exposed rocks."

Figure 12 summarizes historical grazing trends for three classes of livestock and nine counties in northeastern Oregon and southeastern Washington. Figure 13 provides early grazing trend information for Umatilla National Forest from 1906 to 1939 (USDA Soil Conservation Service 1941).

Domestic livestock grazing in early 1900s was not the only factor that may have affected forest regeneration; in some areas, impact from native ungulates (deer, elk) was more pervasive and, unlike domestic animals, continues at moderate or high levels today (Averett et al. 2017, 2019; Case and Kauffman 1997; Endress et al. 2012; Humphrey 1943; Parks et al. 1998; Riggs et al. 2000).

Elk are indigenous to the Columbia River basin but were not common before 1850. Market and subsistence hunting by Euro-Americans nearly exterminated elk by 1900 (Oliver et al. 1994c). Elk were reestablished by importing animals from Yellowstone National Park and Jackson Hole, Wyoming in 1911-1913, 1918, and 1930 (Bright and Powell 2008, Cliff 1939, Tucker 1940). Elk populations expanded quickly after they were reintroduced to the Blue Mountains, increasing from 360 animals in 1921 to 13,000 animals by 1941 (fig. 15).

A dense sod of perennial graminoids provided nutritious forage for ungulates, but it also influenced tree regeneration patterns. Competition for soil moisture and nutrients, as well as allelopathic inhibition by grass and other herbs (Fisher 1980, Larson and Schubert 1969, McDonald 1986, Randall and Rejmanek 1993, Rietveld 1975), were critical factors limiting establishment of tree seedlings (Cooper 1960, Kolb and Robberecht 1996, Pearson 1942, Rummell 1951).

Livestock herbivory removes plant foliage (forage); plants respond to this defoliation by reducing growth, particularly underground (root) growth (Schuster 1964). This means that livestock grazing may have made it easier for tree seedlings to germinate and survive. This was especially true for open stands of ponderosa pine because competition from graminoids and other herbaceous vegetation was an important factor regulating seedling establishment (fig. 16; Covington and Moore 1994a, Sloan and Ryker 1986, Yazvenko and Rapport 1997).

Figure 14a – Historical photograph showing a band of sheep feeding in dry forest. Sheepherders made an annual migration, following snow as it retreated from lowlands in spring to high country in summer, and then back down to valleys in autumn. It was often noted that peak sheep numbers, and associated damage, occurred from 1890 to 1910 (Tisdale 1961).

Figure 14b – Historical photograph showing a herd of cattle grazing in transitional forest between dry and moist ecological settings (Plenty Bear Ridge). Although cattle grazing occurred later, overall, than sheep grazing, it still caused impacts on dry-forest conditions. As described in this "Influence of Ungulate Herbivory" section, grazing by domestic ungulates (cattle and calves; sheep and lambs; and horses and ponies) changed herbaceous undergrowth plant composition (cattle) and modified woody browse species and production (sheep), and these changes influenced potential for dry forests to support low-severity surface fire.

Figure 15a – Elk being dropped off in Dayton, Washington, northern Blue Mountains, on February 1, 1930. These 30 head of elk were shipped from Montana to Dayton, Washington by railcar on a Northern Pacific train. Cost of shipment was approximately $700. Note: Importing elk into the northern Blues began in 1909, when a Game Commission was formed and 4 railcars of elk were shipped west from Yellowstone National Park – 1 carload was delivered to Dayton, 2 carloads to Pomeroy, and 1 carload to Clarkston for the Lewiston Flats area. Each carload contained 36 cows and 4 bulls, and 1909 shipping costs for elk ran $4.95 per head.

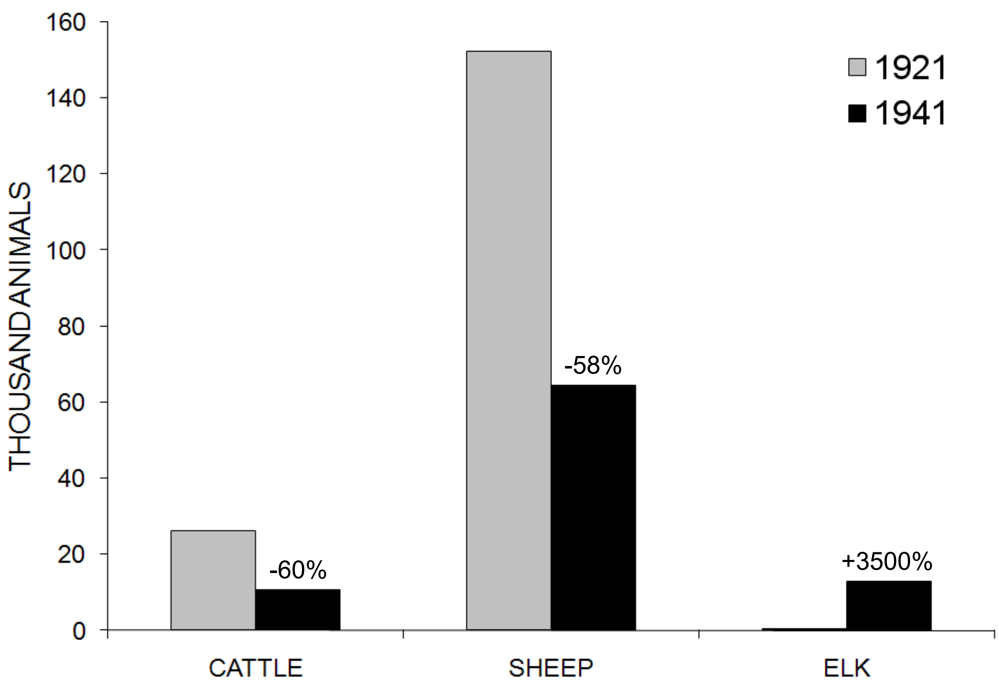


Figure 15b – Ungulate trends for Whitman National Forest in Blue Mountains of northeastern Oregon (data from Pickford and Reid 1943). This chart shows cattle and sheep numbers declining dramatically between 1921 and 1941, and elk numbers increasing from only 360 animals in 1921 to more than 13,000 by 1941.

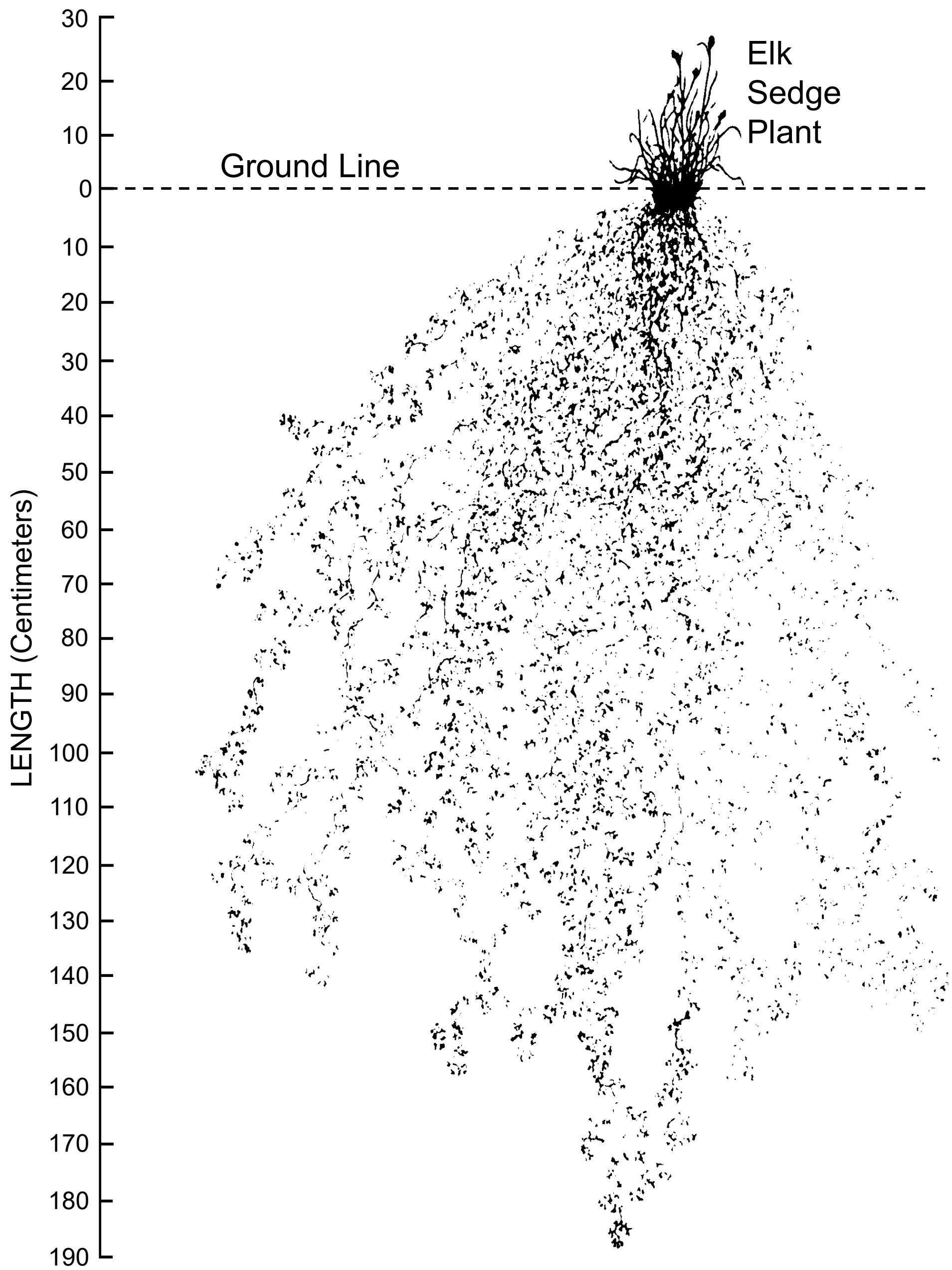


Figure 16 – Elk sedge has a fibrous root system occupying an impressive volume of soil (adapted from Sloan and Ryker 1986). The plant in this diagram is 12 inches tall and 10 inches wide, but its roots spread 56 inches wide and 75 inches deep; dashed line shows ground level. Competition from extensive root systems of bluebunch wheatgrass, Idaho fescue, elk sedge, and other perennial graminoids limits establishment of tree seedlings on dry sites (Cooper 1960, Munger 1917, Weaver 1967b). In some contexts, inhibitory effects of rhizomatous herbs is viewed as a management problem because herbs function as 'competing vegetation' by limiting survival of planted tree seedlings. But in an ecological context, competition from graminoids and other herbaceous vegetation is easily perceived as beneficial because it regulates seedling establishment on a biophysical environment (dry upland forest) where large numbers of seedlings (and eventually mature trees) would easily exceed an area's capacity to support sustainable tree stocking levels (Cochran et al. 1994, Powell 1999).

As often happens, grazing effects were likely influenced by interactions with other factors. Heavy grazing early-on by domestic livestock (particularly sheep; see figs. 12-15) apparently created ideal conditions for establishment of western juniper, other upland conifers, and shrubs. Fire exclusion then allowed them to persist on sites where they might otherwise have perished had a native disturbance regime (surface fire) been allowed to function properly (Young and Evans 1981).

5.1 Active Management Implications Of Ungulate Herbivory

There are obvious interactions between fire and ungulate herbivory as ecosystem processes. Fire relied on herbaceous plant cover as an important spread component, while herbaceous plant communities relied on fire to suppress shrubs, juniper, and other woody vegetation whose shade and plant-suppressing chemicals (produced by allelopathy) would weaken and eventually kill the herbs. Effects of herbaceous cover on fire spread was recognized early on – high levels of domestic livestock were promoted as a fire protection measure because grazing would remove fine fuels and inhibit fuel continuity and fire spread (Hatton 1920).

A restoration section (section 7) describes how it may not be possible to allow prescribed fire to substitute for free-ranging surface (wild) fire without careful and deliberate livestock grazing management to ensure fine-fuel continuity across dry-forest sites (fig. 17). And since prescribed fire occupies a primary position in a hierarchy of active management treatments considered for dry-forest restoration, grazing management should play a critical role in any effort to craft suitable habitat for restoring fire exhibiting characteristic behavior and effects.

Herbs functioned as more than just a fine fuel component to help carry surface fire across dry sites – they also served to suppress tree regeneration (fig. 16). High tree density is a common problem throughout eastern Oregon and eastern Washington (Powell et al. 2001), so the importance of this inhibitory effect on tree establishment should not be underestimated.

Speculation about an interaction between livestock grazing and tree regeneration is frequently mentioned in scientific literature (Cooper 1960, Madany and West 1983, Steele et al. 1986, Zimmerman and Neuenschwander 1984, and others). However, it is often difficult to establish a cause-and-effect relationship between grazing and tree regeneration, perhaps because of difficulty in establishing a carefully controlled research framework accounting for potential influences of confounding factors.

Rummell (1951) studied tree regeneration patterns for grazed and ungrazed areas in central Washington. He implied there was a direct relationship between degree of forage utilization by livestock and density of ponderosa pine reproduction. But there were important differences in representation of pinegrass and elk sedge between grazed and ungrazed areas, and differences were not necessarily explained by palatability or other grazing factors.

Rummell's (1951) study suggests that grazing may not have been a primary factor affecting tree regeneration because elk sedge and pinegrass – two plant species known to limit tree seedling establishment on dry-forest sites (Sloan and Ryker 1986) (fig. 16) – were apparently reacting to some influence other than grazing. Perhaps they were reflecting variations in site potential (e.g., plant association) from one portion of his study area to another?

Figure 17 – Fenceline contrast related to livestock grazing. Domestic and wild ungulates (see figs. 12-15) sometimes cause dramatic effects on abundance and vigor of herbaceous plants. Grazing animals cause many secondary influences for dry-forest sites: (1) they can disrupt a prevailing surface fire regime by removing much of a fine-fuel component (herbs) functioning as a fire carrier; (2) they reduce herbaceous competition for tree seedlings, thereby allowing many more trees to become established than would otherwise occur; and (3) they reduce abundance of aspen, cottonwood, serviceberry, and other broadleaf trees and shrubs (Endress et al. 2012).

When Miller and Halpern (1998) studied effects of grazing and environment (climate) on tree establishment for Cascade Range in Oregon, they noted that "the strongest support for the absence of grazing-induced changes comes from establishment trends on south-facing slopes. Here, despite widely varying dates of closure to sheep, tree invasion remained relatively synchronous among transects and was closely timed to the onset of wetter weather" (Miller and Halpern 1998, p. 280). In other words, climate apparently had more influence on tree regeneration patterns for this Cascade Mountains study area than livestock grazing or the magnitude of its impact.

Jon Skovlin and others (1976) studied cattle grazing methods on ponderosa pine ranges and, although it was not the primary objective of their investigation, they noted an impressive, 12-fold increase in tree seedling density during the 13-year period of their study. Once again, however, this increase was apparently unrelated to cattle use since the same response occurred in units grazed by wildlife only, and because there was no statistically significant seedling density difference between different cattle-grazing intensities (Skovlin et al. 1976).

Livestock grazing on national forest lands was sanctioned after creation of USDA Forest Service by Transfer Act of 1905. In my opinion, high grazing levels of the early 1900s, particularly by sheep (figs. 12-15), were sufficient to affect tree regeneration by reducing herbaceous vegetation (by reducing herbaceous competition with seedlings), and by exposing mineral soil for tree-seed germination; I would not expect the substantially reduced livestock grazing levels of today to exert a significant influence on tree regeneration patterns for these lands.

6. INFLUENCE OF SELECTIVE CUTTING

Fire exclusion allowed a multi-layered structure to develop on a majority of dry-forest sites (influence of fire exclusion is discussed in section 4 of this white paper). After 40 or 50 years of fire exclusion, these areas often had an overstory of old-growth ponderosa pine and western larch, and an understory of Douglas-fir, grand fir, and occasionally, limited amounts of lodgepole pine. When wood products were harvested from these stands beginning in 1940s and 1950s (see appendix 2), many overstory trees were removed for these reasons (Powell 1994):

- Pine was usually old (often 200 years or more) and was adding little or no timber volume because of its slow growth. Since old pines may have low vigor and little resistance to insect attack, they were often harvested before being attacked and killed by western pine beetle or mountain pine beetle (Cowlin et al. 1942, Keen 1936, Weidman and Silcox 1936).
- One reason for low vigor in old-growth pine trees was competition from a dense tree understory, and this understory would not have been present if a frequent surface fire regime had been allowed to continue its historical role (see fig. 46 later in this white paper).
- Old-growth ponderosa pine has a much higher selling value than associated species. Because of this economic advantage, harvesting ponderosa pine provided abundant Knutson-Vandenberg (K-V) receipts, which could then be used for noncommercial thinning, wildlife and range improvements, and other land management activities in timber sale areas.
- As forestry intensified in the 1950s to meet increasing lumber demands after World War II (Fedkiw 1999, MacCleery 1992), dry mixed-conifer stands began to be managed. Mature pines and larches were removed from the overstory, followed by a thinning in an immature understory of Douglas-fir and grand fir (Dezellem 1983).
- An overstory removal strategy seemed to make good sense – it avoided the cost of tree planting, an expensive practice; it avoided an undesirable appearance associated with clear-cutting; it maintained the pleasing aesthetics of a green, forested setting; and it capitalized on previous growth of understory trees existing for 60 years or more.
- Understory trees (primarily Douglas-fir and grand fir) were viewed as a fast-growing gift of nature (i.e., not a result of intentional management), so why shouldn't they provide the next crop of timber products (Dezellem 1983)?

Some level of selective cutting has been occurring ever since Euro-American emigrants settled in the Blue Mountains (selective cutting is defined on page 70). Heavy commercial timber harvests in a northwestern pine region (eastern Oregon and eastern Washington) began in the 1880s (fig. 18) (Weidman and Silcox 1936), although some previous harvesting occurred in conjunction with gold extraction and mineral development (Lindgren 1901).

Mining activity in lower Columbia River basin can trace its origins to discovery of gold on Canal Gulch of Orofino Creek, a tributary of Clearwater River, by Captain E.D. Pierce in 1860. In early spring of 1861, a miner from Pierce's party sold $800 worth of gold dust at Walla Walla, and a stampede to the gold fields soon followed! By May of 1861, there were over a thousand miners in the Pierce City/Orofino area. Lewiston was founded in June 1861, and it quickly became an important center for resupplying the mines (Tucker 1940).

Figure 18 – Early timber harvest in Blue Mountains (also see appendix 2). Relatively heavy commercial harvest began in limited portions of lower Columbia River basin in 1880s (Weidman and Silcox 1936), with early harvest concentrated near settlements, mining camps, and railroads. Large ponderosa pines and Douglas-firs were removed early on because of their desirable wood qualities and their abundance in easily-accessible, park-like stands at lower elevations (Oliver et al. 1994c). Settlers and homesteaders, however, often had a different species preference because their favorite tree tended to be 'tam-brack' (western larch) because it was durable (decay resistant), young trees furnished long, straight poles, and large trees split easily into the finest rails ever enclosing a pig pen or garden patch.

Note: early range was legally open, as much of it still is today, so settlers and farmers had to fence free-range livestock **out**, rather than livestock producers being responsible for fencing their animals in and thereby preventing damage to settlers' gardens or planted crops (Robbins 1997, Robbins and Wolf 1994).

For the Blue Mountains, gold was discovered in Griffiths Gulch, located a few miles southwest of Baker City, Oregon, in autumn of 1861 (Lindgren 1901, Mosgrove 1980). Other discoveries soon followed, leading to a large influx of prospectors and miners in 1862. They established Auburn, Canyon City, Granite, Sumpter, Susanville, and other mining towns; by 1890, Baker, Union, and Grant counties already had a combined population of 23,900 (Lindgren 1901).

Within a year after gold was discovered in John Day River valley (in June 1862 near Canyon City), a sawmill was operating to provide lumber for miners building flumes and sluiceways (Robbins 1997). Early cutting to supply mines and their adjacent settlements was substantial in localized areas; a turn-of-the-century map of Oregon's forests showed significant timber harvest near Sumpter by 1900 (Gannett 1902, Thompson and Johnson 1900).

Since an extensive road network was not present in the Blue Mountains during a mining era, widespread timber harvests did not occur. A far ranging road system eventually evolved in the Blue Mountains as wagon roads were developed for hauling wood and rails out to farms and ranches (Tucker 1940, Mosgrove 1980).

Early Euro-American settlements were often located in river bottoms containing forests of black cottonwood. Since cottonwood was unsuitable for house logs or fence rails, settlers needed access to mountain timber. The favorite mountain timber of early pioneers was tamarack or western larch (they called it 'tam-brack') because it was durable (decay resistant), young trees furnished long, straight poles, and large trees split easily into the finest rails ever enclosing a pig pen or garden patch (Tucker 1940).

As emigrants settled in the fertile river valleys, they were accompanied by large herds of cattle and horses roaming free on adjoining foothills of bunchgrass. Once settlers began growing grain (Humphrey 1943) and needed more timber to fence their fields and exclude free-range livestock, the road system was extended to access additional larch forest. Several roads in the northern Blue Mountains (Scoggins Ridge and Iron Spring-Clearwater, for example) were developed by 1870-1875 during this early Euro-American settlement era (Tucker 1940).

Later, some of these same roads were used to harvest timber for production of railroad ties. Although other species were also used, resinous, durable woods of ponderosa pine and western larch were found to be ideal for producing railroad ties (Robbins and Wolf 1994, Tucker 1940).

Beginning in early 1940s, national forest tree harvests increased to meet a heightened demand during World War II, and for new housing after the war (Fedkiw 1999). After World War II, ponderosa pine and other species were intensively harvested to feed a rapidly growing market for clear lumber for home construction, railroad ties, and to fabricate shipping crates for apples and other fruit crops (Bolsinger and Berger 1975, Gedney 1963).

Due to market conditions, early selective cuttings were typically a 'diameter-limit' harvest with the largest trees being removed (O'Hara et al. 2010). Diameter-limit cutting gradually alters forest composition (Abella et al. 2006) by removing economically valuable trees (large-diameter ponderosa pines, western larches, and Douglas-firs), leaving behind a high proportion of small grand firs and Douglas-firs.

The following passage describes how partial cutting was applied in early ponderosa pine forests of Oregon (Munger 1917).

> "The system of cutting which seems to be ideal for this type of forest is a form of selection cutting. Periodic cuttings are made, in each of which all the overmature and thoroughly ripe trees in the stand and all the defective ones are removed; and the saplings, poles, and young, thrifty trees are left standing to form the basis for the next crop.
>
> No tree is removed until it has reached its majority, so to speak, and no old, slow-growing tree is allowed to stand and occupy space which should be devoted to young and rapid-growing trees. It is customary to set an appropriate diameter limit of from 16 to 22 inches, the majority of the trees above which limit are cut, and those below left."

Why was diameter-limit cutting used if it favored low-value species (true firs) instead of valuable ponderosa pine and western larch? Under market (economic) conditions of that era, selective cutting was viewed as a wise use of natural resources because it captured economic value of mature trees before they died, thereby initiating a rudimentary level of forest management (O'Hara et al. 2010).

With diameter-limit cutting, low-value trees were harvested to whatever extent allowed by prevailing market conditions. Many low-value species were left with the hope that some would become merchantable by the next silvicultural entry in 40-60 years. The following passage describes this situation for western white pine (Haig et al. 1941), but the same concept was also true for ponderosa pine forests (Starker 1915).

> "The low values are due to high susceptibility to heart rot of western hemlock, grand fir, and some other species, and to the fact that the selling price of lumber manufactured from these species is often insufficient to meet production costs even if nothing were paid for the standing timber. Where trees of such species are not defective, the Forest Service policy has been to leave them uncut in the hope that at some future time they can be sold at a profit. But leaving these low-value species on areas that are cut over encourages their reproduction and tends to decrease the proportion of western white pine in the reproduction – an undesirable result both silviculturally and economically" (Haig et al. 1941).

In many respects, selective cutting had the opposite effect of native disturbance processes operating on dry mixed-conifer sites. Surface fire was historically a dominant disturbance process (Agee 1993, Cooper 1960, Munger 1917, Sloan 1998a, White 1985, Wright and Agee 2004), and it discriminated against fire-intolerant invaders (grand fir and Douglas-fir) while favoring fire-tolerant trees with high, open crowns (ponderosa pine and western larch).

In contrast to surface fire, selective cutting on dry-forest sites removed fire-resistant ponderosa pines and western larches, while allowing grand firs and other fire-susceptible species to remain and flourish (Filip 1994, Filip and Schmitt 1990). [Appendix 2 provides pictures and descriptions for early 1940s selective cutting in the central and southern Blue Mountains.]

Dry forests of the interior Pacific Northwest have a history of high-grading (early selective cutting was often implemented as high-grading). High-grading did not seek to regulate stand structure; instead, harvesting simply removed timber. High-grading can be dysgenic by leaving an inappropriate stand structure comprised of low-vigor trees susceptible to insect and disease attack (Carlson and Lotan 1988, Cochran 1998, Laudenslayer et al. 1989).

Late-seral species favored by selective cutting had less value for timber products than ponderosa pine. Early Blue Mountains foresters recognized that partial cutting could have an undesirable impact on species composition and timber values, as described below.

> "White fir, though of slower height growth, is far more tolerant than bull pine, reproduces fairly freely, and under normal conditions would naturally supplant the pine in time. This condition has been greatly aggravated in the portions that have been lumbered by cutting the pine and leaving the white fir. The fir, often already on the ground under the pine, springs up, and pine reproduction is thus impossible" (Kent 1904).
>
> "In all sales on this Forest, care should be exercised in marking the timber not to leave the cutting area in such condition that a valuable stand be supplanted by inferior species. White fir, though occasionally used for fuel when no better species are available, makes poor fuel wood, while for saw timber it is all but valueless owing to the fact that nearly all mature trees are badly rotted by a prevalent polyporus, and the wood season-checks badly. Unless care is taken this species is prone to supplant such species as yellow pine and tamarack since it is much more tolerant of shade in early life" (Foster 1907).

Evaluating Disturbance Evidence To Interpret Successional Trends

Presence or absence of selective cutting evidence can be used when evaluating the successional history of dry-forest ecosystems. When first entering a dry-forest stand, look up into the highest canopy to see if widely-spaced, old-growth tree crowns are found there. If they are, their presence suggests a relatively stable stand structure long free of severe disturbance. Then, look around you at eye level – this generally reveals abundant young trees beneath the old overstory. This finding suggests an unstable structure because a new tree cohort often follows disturbance. But, does a careful search at ground level fail to reveal typical disturbance indicators, such as fire scars at the base of live trees or tree stumps from selective cutting?

At this point in your investigation, you might come to the following conclusions: a relatively open pine stand may have occupied the area more than a century ago (the upper cohort of old trees). Tree seedlings competed unsuccessfully with wildfire (section 4) and herbs (section 5), so tree density was kept relatively low. And, this rationale could help explain why the old trees have large diameter – low understory tree density contributes to rapid overstory growth; we should remember that large tree diameter is not solely a result of advanced age.

You then surmise that cattle grazing associated with Euro-American settlement may have weakened the ground cover. Tree seedlings, no longer held in check by severe herbaceous competition, established abundantly whenever a good seed crop and favorable germination conditions happened to coincide. As grazing continued, however, cattle destroyed or damaged many seedlings, and few of them reached sapling size. But once unfettered grazing was regulated, herbivore pressure declined (figs. 12, 13, 15), and more seedlings could then develop normally, eventually resulting in abundant small trees beneath an overstory canopy (see fig 46).

6.1 Active Management Implications Of Selective Cutting

Ponderosa pine, a keystone species for dry-forest ecosystems, was preferentially removed during historical timber harvest programs, particularly for central and southern portions of the Blue Mountains where selective harvests were especially common (O'Hara et al. 2010). Not only did harvest of ponderosa pine result in removal of a tree species with high resistance to disturbance processes, but harvests were often conducted in such a way as to inadvertently favor other species with lower resilience to disturbance (e.g., Douglas-fir and grand fir).

Selective harvests also removed larger-diameter trees, so they functioned as an overstory removal by releasing small seedlings and saplings in an understory. This means that selective harvests often caused a pronounced change in vertical forest structure. [But, conversely, light selective harvest could be viewed as emulating tree mortality caused by western pine beetle (see fig. 36 later in this white paper).]

Active management treatments can be implemented as one component of a restoration program to help recover and then sustain ponderosa pine as a keystone tree species of dry-forest ecosystems (section 7 describes restoration options in more detail). In some situations, it may first be necessary to remove some ecologically inappropriate composition (grand fir and Douglas-fir) in order to free up growing space for occupancy by ponderosa pine (including planting ponderosa pine, if need be, to help restore its historical abundance).

7. RESTORATION OF DRY-FOREST ECOSYSTEMS

As a result of substantial reductions in park-like ponderosa pine forests throughout interior Pacific Northwest, they are now considered to be a threatened ecosystem of the United States. Reed Noss and others described loss of park-like ponderosa pine forest in their endangered ecosystems report: "conifer forests that depend on frequent fire, notably longleaf pine in the southeast and ponderosa pine in the west, have declined not only from logging but also from increases in tree density and from invasion by fire-sensitive species after fire suppression. These kinds of changes can cause the loss of a distinct ecosystem as surely as if the forest were clearcut" (Noss et al. 1995).

Recurrent underburns are now extinct following a long-standing policy of fire exclusion (Stephens and Ruth 2005). Land managers responded to wildfire with Smokey Bear fire prevention campaigns, an arsenal of slurry bomber airplanes, mountaintop fire lookouts, aerial reconnaissance flights, radar-assisted lightning detectors, and crews of elite smokejumpers and specially trained, hotshot firefighters. In many respects, fire exclusion has been effective enough to be considered the most successful program in USDA Forest Service history (Fedkiw 1999).

Replacement of park-like ponderosa pine with mixed-conifer forest was caused by human alteration of a disturbance regime. Following at least 75 years of fire exclusion in the West, we now have millions of acres where normally fire-resistant ponderosa pines are surrounded by shorter trees that grew to 40, 50, or even 75 feet tall, but only because they escaped fire when just three or four feet high (Arno and Allison-Bunnell 2003, Mutch et al. 1993, Powell 1994).

If man had not altered the disturbance regime of dry-forest sites by suppressing frequent surface fire, many younger trees would have perished while still small (Barrett 1988, Powell 1994, Sloan 1998b, Steele et al. 1986). And since smaller trees function as 'ladder fuel,' easily lifting surface fire up into a forest canopy, crown fires are more common now than historically, leading to our contemporary perspective that *crown fire, not timber harvest, is currently the greatest threat to old forest on dry sites* (fig. 19). Climate change is a 'double-whammy' for these forests because crown fire and drought act synergistically (Boag et al. 2020, Savage et al. 2013).

7.1 Characterization Of Reference Conditions

Restoration efforts benefit from characterization of reference conditions, which disclose how vegetation has changed over time as a result of human influences and disturbance; they help us understand what an ecosystem is capable of, how disturbance functions, and how ecosystems recover after disturbance (Falk 1990, REO 1995). They also provide clues about how we got where we are now, and they help decide where we want to be in the future (Gruell 2001).

Compiling collaborative historic evidence from photographs, aerial photography, maps, reports, and other historical sources is used to derive reference conditions (Egan and Howell 2001, Evans 1991, Powell 1999a). As Don Falk (1990) put it: "restoration uses the past not as a goal but as a reference point for the future. If we seek to recreate the temperate forests, tallgrass savannas or desert communities of centuries past, it is not to turn back the evolutionary clock but to set it ticking again."

Figure 19 – Crown fire in Blue Mountains of northeastern Oregon (top photo from Powell 2010; bottom photo shows aftermath of crown fire at 1996 Wheeler Point fire site on Heppner Ranger District). In dense forests with large amounts of canopy fuel loading, fires are very intense and travel rapidly from one tree crown to another. Crown fires are an important process for perpetuating lodgepole pine, grand fir, and subalpine fir forests, although any particular area seldom experiences a stand-initiating crown fire more often than once every 80 to 110 years (see table 3). Historically, crown fire was rare on dry-forest sites; that is no longer true following major changes in species composition, structure, and density over the past century (Arno and Allison-Bunnell 2002).

Seven decades ago, 74% of commercial forest in eastern Oregon and eastern Washington was classified as ponderosa pine, much of it old-growth (Cowlin et al. 1942). By the late 1970s, at least 25% of Pacific Northwest ponderosa pine type had been replaced by mixed-conifer forest (Barrett 1979); reductions were apparently greater for northeastern Oregon where ponderosa pine declined by more than 50% between 1936 and 1980 (fig. 20; Powell 1994).

These forest inventory trends demonstrate that dry mixed-conifer forest, frequently overstocked with Douglas-firs and true firs capable of persisting in overcrowded stand conditions for relatively long periods (see fig. 10), have replaced ponderosa pine and now cover many eastside landscapes (Mason and Wickman 1994) (note: in a potential vegetation context used for this white paper, 'dry mixed-conifer' and 'dry forest' are synonymous terms).

The following comments suggest that a trend of ponderosa pine being replaced by other species was recognized more than 50 years ago (Gedney 1963).

> "If present trends continue, the proportion of ponderosa pine will be less in the future than at present. In 29 percent of all the pine sawtimber types, there is no understory of pine, only other species – Douglas-fir, white fir, and lodgepole pine. In another 27 percent of the pine sawtimber stands, the understory is a mixture of young ponderosa pine and other species. On more than half of this area, species other than pine predominate. Unless something happens to change this relationship, or unless more intensive forest management is undertaken, about 40 percent of the pine sawtimber type is likely to shift to some other type."

7.2 Forest Health Considerations

Altered disturbance regimes often result in forest health problems such as insect outbreaks or stand-initiating fires (figs. 7 and 19), but conditions causing these problems take decades or centuries to develop. An example of altered disturbance regimes is provided by a recent U.S. Fish and Wildlife Service analysis of 146 threatened, endangered, or rare plant species for which credible fire effects information is available. It found that 135 of these plants (92%) either benefit from fire or are found in fire-adapted ecosystems, suggesting that declines in their abundance or persistence are likely influenced by fire exclusion (Hessl and Spackman 1995) (and, such declines are often viewed as indicators of an 'unhealthy' ecosystem).

Plant succession, in combination with human influences including climate change, is a recipe for forest health issues; insect outbreaks and disease epidemics may be little more than symptoms of an underlying problem (Shlisky 1994, Sloan 1998b, Steele 1994). Forest ecosystems adjust to altered disturbance regimes with the only tools available – insects, diseases, wildfire, and to a limited extent, microbial decomposition (Harvey 1994; fig. 8). In this respect, forest health functions as a unifying concept because it integrates effects of forest succession, tree physiology, and insect and disease susceptibility (Clark et al. 1998).

Forest health. Perceived condition of a forest based on concerns about such factors as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance. Perception and interpretation of forest health is influenced by individual and cultural viewpoints, land management objectives, spatial and temporal scales, the relative health of stands comprising the forest, and the appearance of a forest at any particular point in time (Helms 1998).

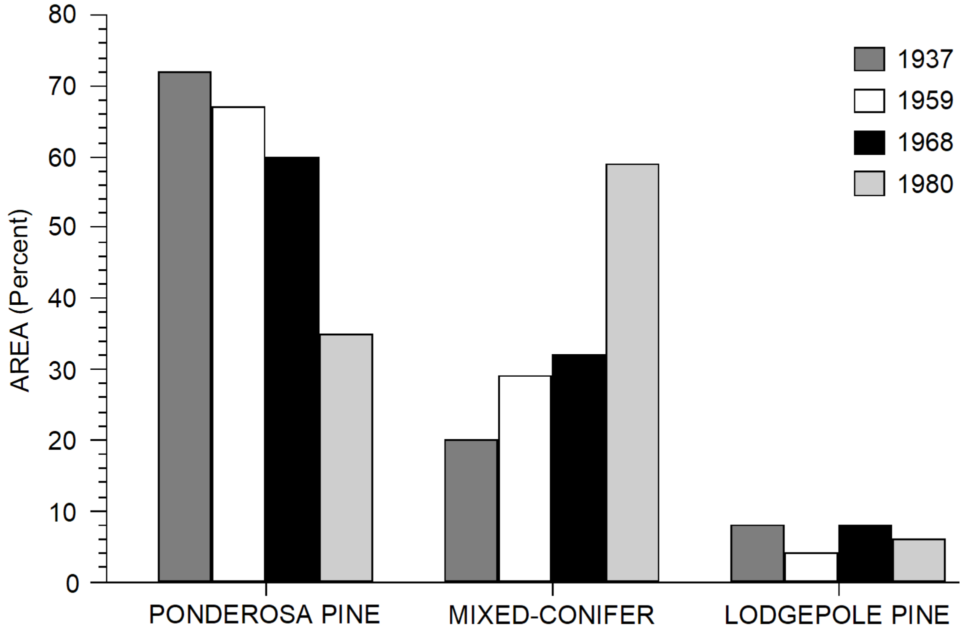


Figure 20 – Change in forest cover types for Malheur National Forest, 1937-1980 (from Powell 1994). Ponderosa pine forest declined by more than half between 1937 and 1980, mixed-conifer type increased by an equivalent amount during this period, and lodgepole pine type remained relatively constant. This figure shows that mixed-conifer forest – prime habitat for defoliating insects – increased by 195% between 1937 and 1980. An increase in mixed-conifer forest was an important reason for unprecedented magnitude of a Blue Mountains budworm outbreak between 1980 and 1992.

Once a forest's vigor falls to low levels, insects and diseases quickly become catalysts of change (Gast et al. 1991, Wickman 1992, and many other citations in References section). Without application of restoration treatments soon (during next 15-30 years), it is very likely that the Blue Mountains' legacy into the second half of 21st century will be large, homogenous landscapes recovering from uncharacteristic wildfires and other ecosystem setbacks on a scale unprecedented in recent evolutionary history (Mutch et al. 1993, Sampson et al. 1994).

Landscape-scale changes have occurred to such an extent that simply reintroducing native disturbance processes (wide-ranging surface fire, for example) may produce effects outside of any historical precedent. These effects are undesirable because they would move an ecosystem farther away from, rather than closer to, a desired future condition (Landres et al. 1999). In situations where current conditions deviate significantly from reference conditions, some type of restoration treatment (such as reducing tree biomass or herbivore populations) may be needed before a disturbance process can be successfully reintroduced (Aplet and Keeton 1999, Case and Kauffman 1997, Oliver et al. 1994b, Pickett and Parker 1994).

One example of this concept is that standing and surface fuels often accumulate to an extent where prescribed fire cannot be applied safely unless preceded by a mechanical treatment such as thinning (Arno et al. 1995, Feeney et al. 1998, Fiedler et al. 1996, Fiedler et al. 1999, Graham et al. 1999). Caution about reintroducing fire is appropriate because fire exclusion, by itself, did not create our current problem, and fire's reinstatement will not cure it. Fire is an ecological catalyst taking its character from whatever surrounds it. Ecosystems with uncharacteristic conditions will yield uncharacteristic fires (see fig. 19).

To successfully reinstate fire, we first need to restore suitable habitat for desirable fire regimes. The woods need to be thinned before reintroducing wildland fire, but it's not just the trees that matter, it's also the grass. Without careful and deliberate grazing management to ensure fine-fuel continuity (see fig. 17), it may be difficult to reestablish a short-interval fire regime on dry sites (Madany and West 1983, Pyne 1997, Rummell 1951, Starns et al. 2019).

Exclusion of low-severity fires and selective harvesting of large, old trees have homogenized eastside landscapes, especially for a montane, mixed-conifer zone at mid elevations (Hessburg et al. 1994, 1999; Lehmkuhl et al. 1994). In drier forests of eastern Oregon and eastern Washington, alteration of a disturbance regime by suppressing fire has de-fragmented inherent patterns of fuel distribution and accumulation, thereby increasing potential for large wildfires (Hessburg et al. 2005, Rochelle et al. 1999) (see fig. 19).

Unnaturally large, contiguous areas of densely stocked and highly stressed trees provide an increased food base for defoliating insects (Gast et al. 1991, Hessburg et al. 1994, Mason and Wickman 1988, Williams et al. 1980), and these forest conditions are also more favorable for occurrence of parasitic plants (Gast et al. 1991, Zimmerman and Laven 1984) and fungal pathogens (Filip and Schmitt 1990). Historically, defoliating insects and bark beetles tended to affect only small patches of forest, but such insects now occupy large, landscape-scale areas during episodic outbreak events (Hessburg et al. 1994, Powell 1994, Wickman 1994).

Reducing stand density to minimize moisture and nutrient stress for individual trees, and then reintroducing fire – a natural thinning agent – are primary objectives of restoration management, but these activities are controversial to some publics (Agee 1994, Arno and Ottmar 1994). Scientists emphasize that restoration efforts must be focused on a landscape scale to reestablish a mosaic of forest types and structural stages that will, in turn, reduce continuity of food sources for defoliating insects (Mason and Wickman 1994, Torgersen 2001), while also crafting habitat for free-ranging wildfire (Arno and Ottmar 1994).

Ecosystems Out Of Balance

How did fire exclusion, in combination with selective tree harvest and ungulate herbivory, contribute to dry-forest ecosystems that are now out of balance? These ecosystem alterations had a detrimental impact on ecological integrity by modifying vegetation diversity and complexity, particularly at a landscape scale, resulting in forests at risk of uncharacteristic fire effects.

The forests most at risk are those under the most stress because they contain too many trees, or too many of the wrong tree species, to continue to thrive. As these forests get older and denser, competition between trees intensifies, stress increases, and probability of uncharacteristic (catastrophic) change goes up dramatically (Sampson et al. 1994, Sloan 1998a).

Over-protection from fire can render a forest susceptible to serious soil damage when a fire eventually occurs (Grier 1975). When historical wildfire regimes have been altered because society is not prepared to accept fire-related risks to life and property, then land managers should attempt to design thinnings and other silvicultural treatments emulating desirable characteristics of presettlement fire regimes (Kimmins 1997).

Historically, spatial variation in fire intensity was important for providing diversity in landscape patterns (fig. 21). [Munger (1917) provides excellent observations about spatial pattern associated with pine forests; see pages 15-16.] Under a recent fire management paradigm (fire exclusion), the influence of fire as an ecological process has been dramatically reduced, resulting in more homogeneous landscape patterns than would have existed historically (Churchill et al. 2017, del Moral 1972, Hessburg et al. 1999b, 2005; Lehmkuhl et al. 1994, Starns et al. 2019).

A fire exclusion strategy "may lead to tree population explosions and dead fuel accumulation to such an extent that catastrophic adjustments become inevitable. Eventually, catastrophic disturbances such as insect and disease attack and crown fire may cause extensive mortality at a scale never before experienced by the community of organisms" (Covington et al. 1994a).

7.3 Emulating Disturbance Processes

A primary focus of dry-forest restoration is to use silvicultural treatments to emulate intensity, scale, and pattern of historical disturbance regimes. An objective of active restoration is to address fire hazard and insect and disease problems – production of timber, water, and other commodities (if any) is only a by-product of meeting overall restoration objectives (DeGraaf and Healy 1993). Salvaging some dead trees produced by an uncharacteristic crown fire, for example, would be appropriate by "leaving an amount of CWD [coarse woody debris] sustainable under inherent disturbance regimes, not an excess that could set the stage for severe fires and subsequent loss of biological capacity" (Everett et al. 1996, p. 276).

Choice of silvicultural treatment can be important in both ecological and economic contexts. For example, a general trend over past decades has seen a transition from forest harvests producing relatively large, high-quality timber to entries generating small, low-value material at a high production cost (Fiedler et al. 1999, Larson and Mirth 1998, LeVan-Green and Livingston 2003). This trend has obvious implications on economic viability of using commodity revenues to offset costs of dry-forest restoration treatments (Rainville et al. 2008).

Current ecological conditions in dry forests of interior Pacific Northwest suggest that immediate management action is warranted (Bonnicksen 2000b). This management intervention needs to be intensive and to cover wide areas of the landscape, but to be effective it must be substantially different in both impact and appearance from what was done historically (Sampson et al. 1994). This means that management intervention should use an adaptive approach that considers the forest as a fully functioning ecosystem (Hunter 1999, Rowe 1992).

An eminent group of fire ecologists cautioned that a status quo solution for the Blue Mountains "will leave us with seriously degraded ecosystems offering little value in an ecological, aesthetic or economic sense. This option goes counter to the values and concerns of society today, such as biological diversity, beautiful and 'natural' landscapes, healthy plant and animal communities, and long-term productivity" (Mutch et al. 1993). "Restoration efforts will require that we discard the misconception that nature is unchanging and accept the reality that people need to be actively involved in managing forests and woodlands for sustained values" (Gruell 2001).

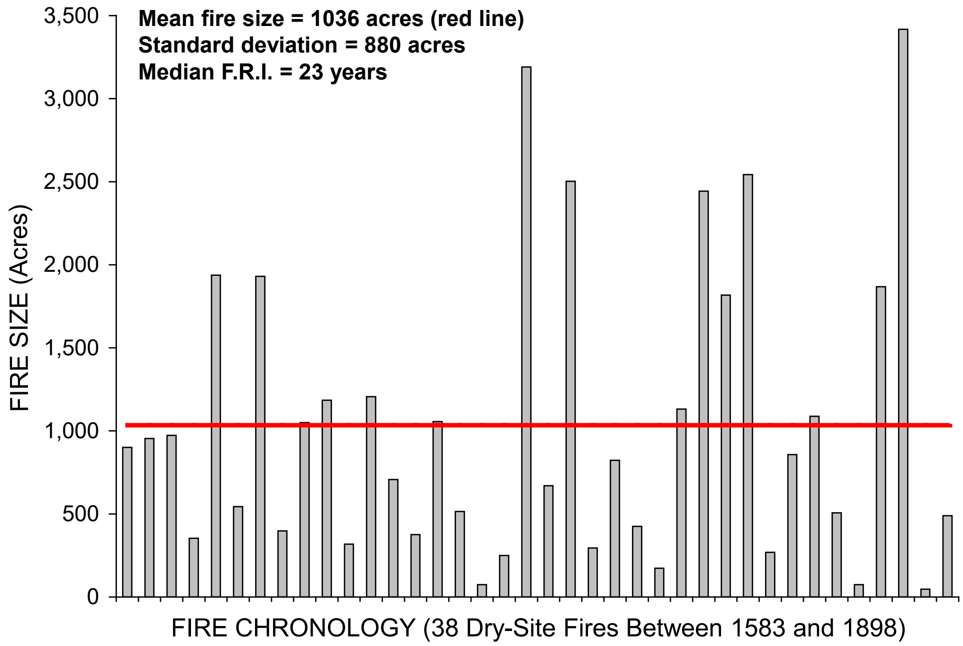


Figure 21 – Spatial variability in fire extent for dry-forest sites in Tucannon watershed, northern Blue Mountains, southeastern Washington (based on data from Heyerdahl 1997). Forty-two individual fire events were interpreted for the watershed, and 38 of them occurred on dry-forest sites. Smallest fire extent on dry-forest sites was 47 acres and largest was 3,417 acres. Average fire extent for 38 dry-site fires was 1,036 acres (red line shows an average). Note that the last recorded fire for this watershed occurred in 1898 (Heyerdahl 1997), although School Fire affected the study watershed in 2005. And, the other three study areas in Heyerdahl's (1997) study (Baker City watershed, Dugout Creek, and Imnaha Creek) also included dry-forest sites, with Dugout Creek area (Malheur NF) consisting entirely of dry-forest biophysical environments.

If the scale of tree harvest does not emulate the scale of native disturbance processes, then we can expect ecosystem changes such as reduced biological diversity and impaired nutrient cycling (Baydack et al. 1999, Eng 1998). Using a variety of cutting patterns, for example, is important to avoid uniform landscapes; grouping cut blocks reduces total amount of edge, minimizes fragmentation, and maintains larger patches of interior forest habitat.

Society's response to deteriorated dry-forest conditions in the interior Pacific Northwest has lacked consensus. Some stakeholders advocate a passive approach, believing that active management would make an unfortunate situation even worse (Beschta et al. 2004). Many proponents of passive restoration contend that knowledge of reference conditions will never be complete, so we should rely on wildfire, insect outbreaks, and other disturbance processes to fix the problem (transform composition and structure) (Frank 2003, Stephenson 1999).

"The present vulnerability of these forest ecosystems requires that we temper our need for more complete information with an urgency created by the current risk of crown fires" (Allen et al. 2002). For example, all of the causal mechanisms are not understood, but it is clear that when plant succession occurs on dry-forest sites in the absence of frequent wildfires, it will result in reduced availability of mineral nitrogen and cause increased accumulation of allelopathic compounds in mineral soil (MacKenzie et al. 2006, Souto et al. 2000, Wardle et al. 1998). And, waiting for more information fails to acknowledge that it has been estimated that up to 32% of all forests in the U.S. suffer high risk of wildfire (GAO 2003) (and the percentage for interior Northwest is much greater than 32% – see figure 43 later in this white paper).

7.4 Desired Conditions For Dry-Forest Sites

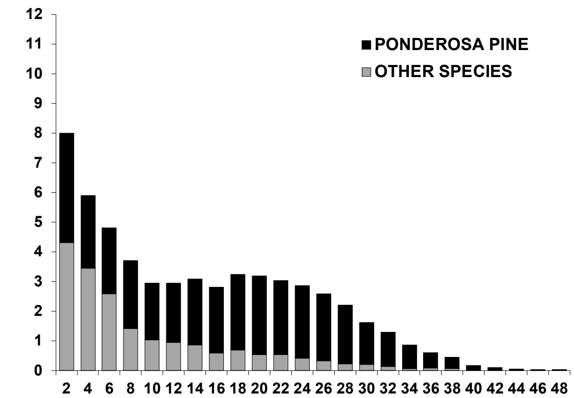
Desired conditions contributing to a sustainable composition, structure, and density for dry-forest sites include the following attributes (Fiedler 2000b).

- An open stand density (40 to 70 square feet per acre of basal area). Stands with a predominance of big trees (> 21" dbh) could be at the upper end of this stocking range and still be viewed as having a sustainable density level.
- A multi-cohort or uneven-aged structure at a stand level, although discrete groups in a stand generally consist of a single cohort (even-aged groups in an uneven-aged stand). Up to 70 percent of even-aged groups in an uneven-aged stand structure would have a single-layer structure (figs. 44-47 later in this paper illustrate groupy or clumpy structures). Typical group size should range from 0.1 to 0.6 acres (Harrod et al. 1999, Youngblood et al. 2004).
- A predominance of large trees – up to 60 percent of basal area per acre would occur in trees whose diameter at breast height was 21 inches or greater (see fig. 22).
- A composition dominated by ponderosa pine – up to 70% would consist of ponderosa pine (see fig. 22). At least ⅔ of species composition should consist of early-seral, shade-intolerant species to minimize spruce budworm susceptibility (Carlson and Wulf 1989).
- Coarse woody debris (CWD) levels ranging between 5 and 20 tons per acre (Brown et al. 2003). Note that coarse woody debris is typically defined as dead standing and downed pieces larger than 3 inches in diameter (Harmon et al. 1986). Between 4 and 7 tons per acre of a 5-20 ton per acre CWD range would exist as standing snags at a total rate of 6 to 14 stems per acre (2 to 4 snags per acre would be at least 15" dbh) (Harrod et al. 1998).

These desired conditions acknowledge that to bring tree density (basal area) back within an historical range of variation (RV), management activities should emphasize producing fewer but larger trees (Allen et al. 2002, Wright and Agee 2004).
[Section 7.9 provides detailed RV information for composition, structure, and density.]

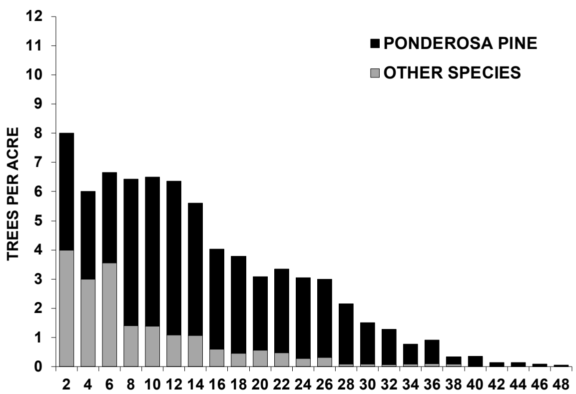
Numerical goals relating to a desired future condition depend on how a metric is quantified. Inventory data collected in 1910-1911 for three forest tracts in the Blue Mountains (fig. 22), for example, show that when tree density is expressed as basal area, 66% of it occurred in trees whose diameter is 21 inches or more. When forest density is expressed as trees-per-acre rather than basal area, stems with a diameter of 21 inches or more comprise only 23% of total stocking (Bright 1912; Munger 1912, 1917).

A characterization of desired conditions should account for a range of disturbance processes and biological legacies, rather than attempting to directly replicate any particular disturbance agent (Foster et al. 1998, Hansen et al. 1991, Urban et al. 1987). Moreover, land managers should focus attention “on the rates at which changes occur, understanding that certain rates of change are characteristic, desirable and acceptable, whereas others are not” (Botkin 1990).



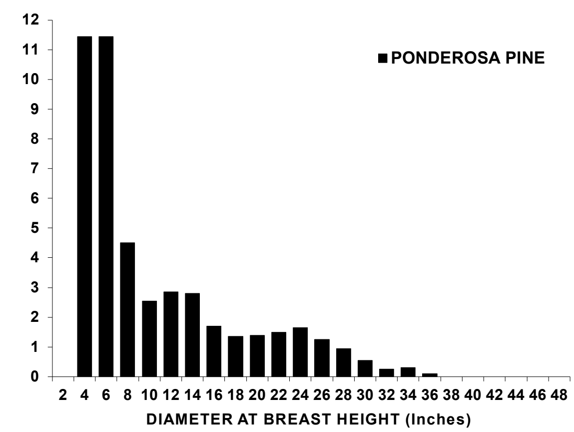
AUSTIN-WHITNEY TRACT

Live trees per acre (1″+ DBH): 56.5
    Ponderosa Pine Proportion.......................... 67%
Live basal area; square feet/acre (1″+) 94.7
    Ponderosa Pine Proportion.......................... 84%
Quadratic mean diameter (Inches) 17.5
    Ponderosa Pine QMD (Inches)..................... 19.5
Stand density index 139.5
    Ponderosa Pine Proportion.......................... 85%
Live trees per acre > 21″ in diameter 15.9
    Ponderosa Pine Proportion.......................... 87%
Live basal area per acre > 21″ DBH 68.0
    Ponderosa Pine Proportion.......................... 87%



LOOKINGGLASS CREEK TRACT

Live trees per acre (1″+ DBH): 73.6
    Ponderosa Pine Proportion.......................... 75%
Live basal area; square feet/acre (1″+) 112.6
    Ponderosa Pine Proportion.......................... 88%
Quadratic mean diameter (Inches) 16.8
    Ponderosa Pine QMD (Inches)..................... 18.2
Stand density index 169.1
    Ponderosa Pine Proportion.......................... 88%
Live trees per acre > 21″ in diameter 17.1
    Ponderosa Pine Proportion.......................... 90%
Live basal area per acre > 21″ DBH 74.8
    Ponderosa Pine Proportion.......................... 91%



WINLOCK'S MILL TRACT

Live trees per acre (1″+ DBH): 46.6
    Ponderosa Pine Proportion........................ 100%
Live basal area; square feet/acre (1″+) 43.8
    Ponderosa Pine Proportion........................ 100%
Quadratic mean diameter (Inches) 13.1
    Ponderosa Pine QMD (Inches)..................... 13.1
Stand density index 69.9
    Ponderosa Pine Proportion........................ 100%
Live trees per acre > 21″ in diameter 6.6
    Ponderosa Pine Proportion........................ 100%
Live basal area per acre > 21″ DBH 24.5
    Ponderosa Pine Proportion........................ 100%

Figure 22 – Selected stand attributes for three forest tracts in Blue Mountains (adapted from Powell 1999b). This data came from relatively large sample areas measured in 1910 or 1911 (sample areas were 258½ acres for Austin-Whitney, 44 acres for Lookingglass Creek, and 20 acres for Winlock's Mill). Data sources are Bright (1912) and Munger (1912, 1917). [Also see table 2 for similar data.]

Alan White (1985) suggests that ponderosa pine regeneration requires a 'safe site' such as the ash bed of a fire-consumed log, where at least a few seedlings could get established before herbaceous and woody fuels recovered enough to support another fire. Although frequent surface fire caused overall seedling survival to be low, long-term survival of saplings successfully making it through this initial fire filter was high. This regime produced low density of small-diameter ponderosa pine trees, so a resulting diameter distribution was relatively flat. This differs from a classical, inverse-J distribution expected for uneven-aged hardwood forests on moist sites lacking a frequent-fire regime (Mast et al. 1999, Powell 2018, White 1985).

Munger (1917) also noted that "yellow pine grows commonly in many-aged stands" (page 17). Historical Blue Mountains inventory data (fig. 22) exhibits a flat diameter distribution expected for uneven-aged stands sustained by frequent surface fires on dry sites.

Adopting a very conservative approach to restoration of dry forests is not a choice of 'no action' because such a strategy accepts risk of high-severity wildfire and other uncharacteristic disturbance events. Upon recognizing that risks of no action are probably unacceptable for most scenarios, managers should design flexible, adaptive treatments to restore more 'natural' conditions (e.g., more historically appropriate conditions), including high levels of spatial heterogeneity for dry-forest sites (Allen et al. 2002; Churchill et al. 2013a, 2013b, 2017; Franklin et al. 2013; Wright and Agee 2004; and many others in References section).

A solution to forest health problems could begin with thinnings to reduce tree density in overcrowded forests, particularly for dry-forest sites where over-crowding was a rare phenomenon before onset of fire exclusion (sec. 4), selective cutting (sec. 6), and ungulate herbivory (sec. 5). These three management activities contributed to creating condition class 2 and 3 conditions described and illustrated in table 5 (Barrett et al. 2010, Belsky and Blumenthal 1997; Covington and Moore 1994a, 1994b; Madany and West 1983; Oliver et al. 1994c; Rummell 1951).

A simulation study examined changes in fire risk associated with active restoration treatments. It found that fire risk at a landscape scale decreased steadily as management intensity increased. After five decades, a no-treatment scenario had nearly 30 percent of a landscape in a high-risk category, whereas active management (thinning and prescribed fire) had 100 percent of a landscape in a low-risk category (Wilson and Baker 1998).

No single restoration solution, however, can hope to precisely reproduce inherent variability of a dry-forest landscape because ecosystems are shaped by a wide variety of disturbance types, frequencies, and intensities (Voller and Harrison 1998). Deciding to take immediate remedial action can result in a philosophical shift toward proactive management to curtail excessive fire and insect impacts, and a shift away from reactive management in response to landscape-scale disturbance events (see fig. 19) (Covington 2003).

A challenge is to integrate a suite of active management treatments to effectively and appropriately emulate natural disturbance regimes of dry-forest landscapes (fig. 23). Successfully meeting this challenge will produce a semblance of historical forest structure and species composition – a desirable outcome not because resulting conditions are historical, but because they are sustainable (e.g., vigorous, self-perpetuating, pine-dominated, and at low risk to stand-replacing fire and defoliating insects) (Fiedler 2000a).

<u>Note</u>: thinning dense clumps of ponderosa pine regeneration (see middle panel of fig. 23) <u>will</u> produce a positive growth response in residual trees (Barrett 1963, 1968, 1970) and place them back on a developmental trajectory toward characteristic stand dynamics. Also note that when released by thinning after a long period in a very dense condition, other tree species seldom respond to additional growing space as well as ponderosa pine does.

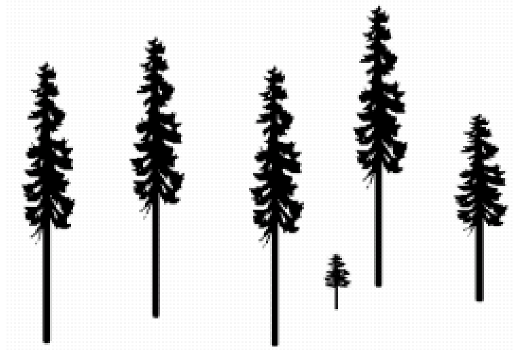
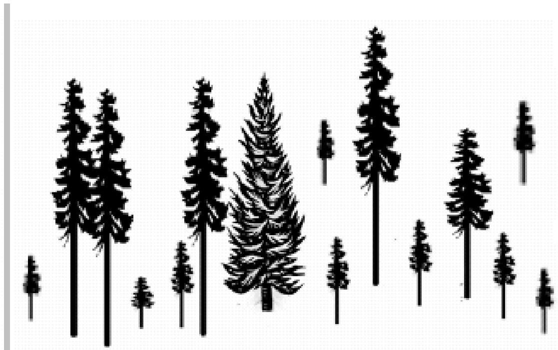
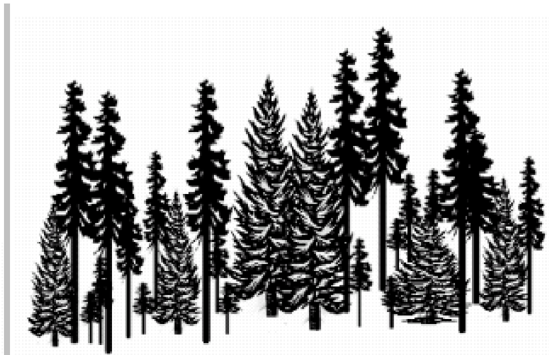
Using burlap to beat out a surface fire in ponderosa pine, Wallowa National Forest, about 1910. As Thornton Munger noted, “Light, slowly spreading fires that form a blaze not more than 2 or 3 feet high and that burn chiefly the dry grass, needles, and underbrush start freely in yellow pine forests. Practically every acre of virgin yellow pine timberland in central and eastern Oregon has been run over by fire during the lifetime of the present forest” (Munger 1917).

Dense ponderosa pine forests developed after fire’s influence was suppressed during the past 100 years. On many dry sites, fire exclusion had an unintended consequence of allowing late-seral tree species (grand fir, white fir, and interior Douglas-fir), none of which are adapted to a recurrent fire regime as small or mid-sized trees, to replace the ponderosa pines.

Thinning and prescribed fire can be used in tandem to restore sustainable and resilient forests on dry sites. Changing a dense forest condition (middle frame) to one that more closely approximates historical composition and structure will go a long way toward allowing us to restore an ecologically important and valuable disturbance process – frequent surface fire.

Figure 23 – Restoration of ponderosa pine ecosystems (from Powell et al. 2001; top photograph from Boerker 1920, bottom two photographs from USDA Forest Service 2001). Soon after its inception in 1905, USDA Forest Service began suppressing wildfire on national forest system lands (Fedkiw 1999) (top). By removing surface fire as a thinning agent, fire exclusion caused tree density to increase substantially on dry sites (middle). Restoration of dry forests features thinning or another mechanical treatment to reduce tree density, followed by prescribed fire for nutrient cycling and to reestablish fire as a properly functioning ecosystem process (bottom) (Arno and Allison-Bunnell 2002, Arno et al. 1995, Fiedler et al. 1996, Fiedler et al. 1999). Dry-forest landscapes are said to have strong ‘ecological memory’ due to the strength of an interaction between an ecological process (surface fire) and landscape pattern. “When ecological memory is strong, landscape pattern is persistent; pattern tends to be maintained rather than destroyed by fire” (Peterson 2002).

Table 5: Fire regime condition classes for dry forests (Brown et al. 2003, GAO 2004, Schmidt et al. 2002, and Zimmerman 2003).

		
CONDITION CLASS 1 (ecosystem maintenance stage)	**CONDITION CLASS 2** (ecosystem alteration stage)	**CONDITION CLASS 3** (ecosystem degradation stage)
Composition and structure: open, park-like, mature ponderosa pine stands; even-aged clumps occurring as an uneven-aged structure; single-layer canopy structure.	**Composition and structure**: beginning to depart from reference conditions; lack of fire allows establishment of fire-sensitive species and a multi-layer canopy structure.	**Composition and structure**: highly altered from reference conditions; fire-sensitive species common; open, park-like appearance completely lacking; multi-layer canopy structure.
Tree density: stocking levels are within an historical range; density remains consistently below lower limit of a self-thinning zone.	**Tree density**: stocking levels in upper half of historical range; density may exceed lower limit of a self-thinning zone.	**Tree density**: stocking levels exceed historical range; total tree density may be 3-4 times greater than for condition class 1.
Vigor: high seasonal energy activity; high capacity to repel or resist disturbance agents such as insects and pathogens.	**Vigor**: moderate to high seasonal energy activity; somewhat diminished capacity to repel or resist insect or pathogen attack.	**Vigor**: little fluctuation in seasonal energy activity; greatly increased susceptibility to insect or pathogen attack.
Fire regime: maintained within or near an historical range; no departure from historical frequency or severity (nonlethal fire regime).	**Fire regime**: frequency reduced and departing from historical range; severity increased, with some mortality of overstory trees.	**Fire regime**: dramatic departure from historical frequency and severity; many fire return intervals missed; larger average fire (patch) size.
Fuel dynamics: surface and total fuel loads maintained at historical levels (between 5 and 10 tons per acre).	**Fuel dynamics**: surface and total fuel loads in upper half of historical range (10 to 20 tons per acre).	**Fuel dynamics**: surface and total fuel loads outside historical range (> 20 tons per acre); increased fuel continuity at landscape scale.
Resilience and risk: high capacity to remain fully functional following fire; low risk of losing key ecosystem components after fire.	**Resilience and risk**: fairly high potential to return to condition class 1 by using prescribed fire; moderate risk of losing key ecosystem components following wildfire.	**Resilience and risk**: low potential to return to condition class 1 by using prescribed fire; mechanical treatments needed before reintroducing fire; high risk of losing key ecosystem components to stand-replacing wildfire.

Note: A strategic assessment for 15 western states (Rummer et al. 2005) found that 30 million acres exist in class 1, 38.4 million in class 2, and 28.5 million in class 3.

7.5 Thinning And Prescribed Fire As Restoration Treatments

Restoration. Restoration refers to holistic actions taken to modify an ecosystem to achieve desired conditions and functions, including the process of returning ecosystems to a properly functioning structure, species composition, and stand density (Dunster and Dunster 1996). Two restoration approaches have been recognized: (1) Active restoration: an approach involving implementation of management activities (prescribed fire, thinning, etc.) to restore appropriate conditions; and (2) Passive restoration: an approach involving removal of stresses that caused ecosystem degradation in the first place, such as cessation of fire exclusion in fire-dependent ecosystems (Rapp 2002).

Although it is not expected that park-like ponderosa pine forest can be fully restored to its historical abundance, some amount of thinning and prescribed fire, applied in proper places and at appropriate times, is needed to help recover integrity and resilience of this important ecosystem (Agee 1997, Arno and Allison-Bunnell 2002, Covington 2000, Fiedler et al. 2001). Thinning and prescribed fire, used alone or in combination, can compensate somewhat for suppression of an historical surface fire regime by reducing high stand density levels, addressing successional advancement (from early- to late-seral tree species), and jump-starting stagnant nutrient-cycling processes (Gundale et al. 2005, Stephens et al. 2009) (fig. 24).

We should consider, however, that some plant and animal species find optimum habitat in early-seral conditions, others in late-seral plant communities, and some in either situation. So when compared with the historical situation, significant changes in disturbance levels (either an increase or decrease) can ultimately degrade biodiversity by affecting proportion and distribution of seral stages at a landscape scale (White et al. 1999).

Fire can be highly stressful to old-growth ponderosa pines, particularly on sites where existing tree density is many times greater than presettlement stocking levels. In these uncharacteristically crowded forests containing low-vigor trees, it is wise to thin first and allow old-growth pines to recover their vigor before subjecting them to additional stress from a prescribed fire (Covington 2003, Fiedler et al. 1996, Scott 1998b, Swezy and Agee 1991). Increased vigor translates into increased resin production and bark-beetle defenses (Perrakis et al. 2011).

Much byproduct from fuel-reduction thinnings will be too small or poor in quality to be commercially valuable for conventional wood products (Fiedler et al. 1999). These thinnings are typically accomplished by using a service contract where a contractor is paid a specified amount per acre, or per tree, to cut or otherwise treat unwanted trees and leave them on-site (Powell et al. 2001).

But leaving unwanted vegetation on-site contributes to an immediate, and often unacceptable, short-term increase in surface fuel loadings and associated fire risk (Arno and Allison-Bunnell 2002, Brown et al. 2003, Mutch et al. 1993). An ideal solution, albeit a costly one in an economic context, is to use stewardship contracting for vegetation treatments, and then remove resulting fuel to an off-site biomass facility for ultimate disposal (fuel could also be treated by using pyrolysis to create bio-oil for energy, and biochar for carbon sequestration) (Lehmann and Joseph 2009).

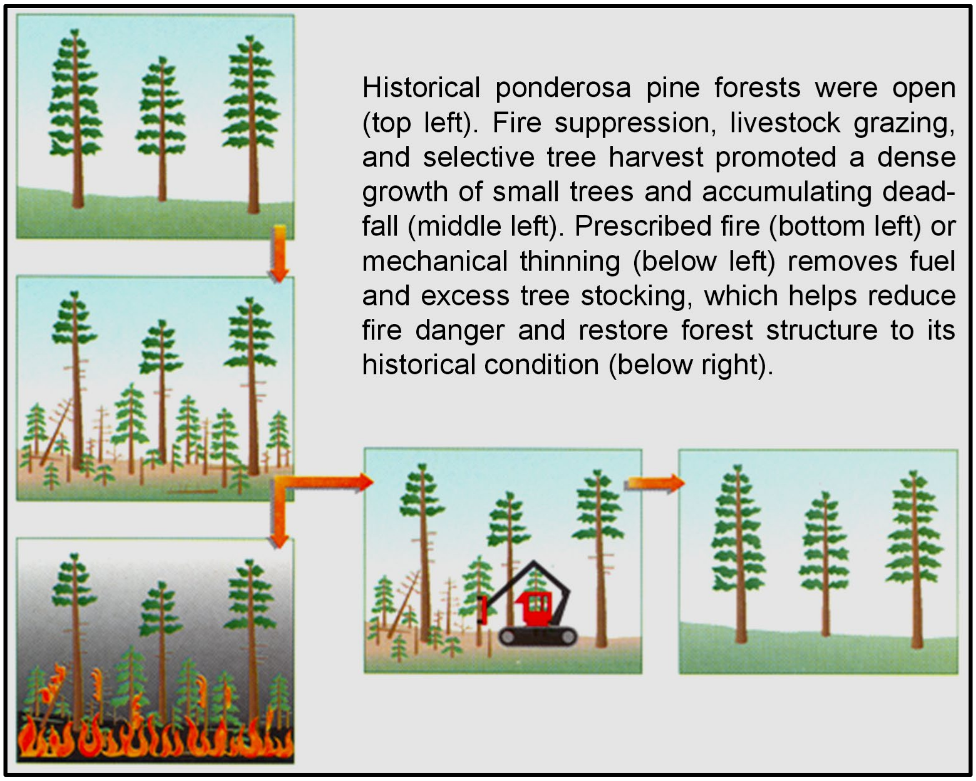


Figure 24 – Correcting a history of fire exclusion (adapted from Phillips 1995). Thinning and prescribed fire are examples of stand-maintaining disturbances that kill from the bottom up (Smith et al. 1997). These treatments need to become more common as one way to address forest health issues resulting from changes in species composition and forest structure caused by fire exclusion, livestock grazing, and selective tree harvest (Johnson et al. 2011, McIver et al. 2013, Stephens et al. 2009, Youngblood 2010).

Several efforts are underway around the western United States to develop processing methods and markets for ever-smaller material. If these efforts succeed, then future thinnings may eventually become commercial by producing biomass material for distillation of ethanol (a gasoline additive) from cellulose, or to generate electricity or biochar (Barbour and Skog 1997).

On forest sites in eastern Washington, residual trees increased growth following surface fires that killed trees in intermediate and suppressed crown classes, but growth increases were greater when thinning was used to reduce overall stand density. Unlike fire, manual thinning did not damage fine roots, so residual trees occupied increased growing space quickly. After overstory trees claimed additional growing space provided by thinning, grasses did not readily invade the site (Oliver and Larson 1996).

Avoiding root damage is important, particularly on dry, rocky, low-productivity sites. For poor-quality sites, up to 40% of a tree's annual net production is invested in fine roots (Keyes and Grier 1981). Since fine roots concentrate near the soil surface, especially on sites with shallow soils, heat generated by prescribed fire has potential to damage or kill them.

For spring prescribed fires, heat effects could "be amplified by the high thermal diffusivity of moist soils, and the low soil temperatures to which roots are adapted after winter. Late summer or early fall fires, on the other hand, occur when roots are inactive, soils are dry and thus good insulators, and roots are adapted to higher soil temperatures" (Grier 1989).

Thinning and prescribed fire also have site disturbance differences. Thinning tends to have minimal soil disturbance, so it favors native understory species more than exotics (non-natives). A combination thinning and burning treatment has intermediate amounts of soil disturbance, and this option favors native and exotic species equally. Burning tends to increase exotic species with little effect (either favorable or unfavorable) on native understory species (Fiedler et al. 2006, Griffis et al. 2001, Kerns et al. 2006).

Stewardship Tree Harvest

Stewardship tree harvest, depending on techniques used and woody debris left behind, may reduce fuels and wildfire hazard in the near term, or it may not. Harvest alone, without also thinning small unmerchantable trees, treating woody debris produced by harvest and thinning, and then using prescribed fire, seldom reduces wildfire hazard over the long term (Gruell 2001).

Fuel hazard studies often came to similar conclusions regarding the importance of treating post-treatment woody debris (slash). 'Lopping and scattering' is a common treatment for thinning slash. In this method, branches are cut from felled trees and scattered to reduce fuel concentrations; if needed, slash is pulled away from residual green trees. Research found that "lopping and scattering still managed to reduce fire behavior levels (mainly because of fuel depth reduction), but application of this treatment should be limited to areas with light fuel accumulations – less than 9 tons per acre" (Kalabokidis and Omi 1998).

Treating or removing post-harvest woody debris provides definite physiological advantages if a wildfire occurs soon after a treatment. When fire occurred in a thinned stand in Arizona, with woody debris having been removed prior to the fire, fire improved residual-tree resin production as compared to an unthinned control (Feeney et al. 1998). Improved resin production promotes defensive chemical compounds enhancing bark beetle resistance (Kolb et al. 1998); without thinning first, fire could benefit bark beetles more than old trees (Perrakis et al. 2011).

More Use Of Prescribed Fire?

In early 1990s, Bob Mutch and other fire scientists recommended that prescribed fire use (fig. 25) be increased tenfold as one way to address forest health concerns for national forests in northeastern Oregon and southeastern Washington (Mutch et al. 1993). A recent survey by Oregon State University, however, showed a stronger public preference for thinning (79% of respondents) than for prescribed fire (20%) as alternative treatments for addressing Blue Mountains forest health concerns (Shindler and Reed 1996, Shindler and Toman 2003).

A proposal to greatly expand use of prescribed fire (Mutch et al. 1993, Mutch 1994) raised concerns about potential impacts on forest productivity, wildlife habitat, and biodiversity. One response to this proposal was that mechanical fuel treatment might be preferable to a dramatic increase in prescribed fire because it offers more control than fire, and more control translates into better protection for dead wood (down logs and snags) (Tiedemann et al. 2000).

Figure 25 – A prescribed fire burning at night. Using prescribed fire is intended to emulate an historical fire regime that sustained open pine forests. For Blue Mountains, surface fires with short flame lengths (3 feet or less) tended to occur at intervals of 5 to 20 years, a frequency favoring thick-barked ponderosa pines and western larches while discriminating against thin-barked grand firs and Douglas-firs (Agee 1996b, Hall 1976, Heyerdahl 1997, Maruoka 1994). Prescribed fire and thinning are restoration activities that can help ensure that dry forests continue to support trees, rather than transitioning to nonforest communities (Boag et al. 2020).

When considering fuel reduction options, mechanical methods might be more expensive than prescribed fire in the short term but are probably more economical over the long run, especially if wildlife habitat (snags and down logs) must be mitigated or replaced after burning (Tiedemann et al. 2000). But down-wood objectives for dry-forest sites need to be compatible with inherent ecosystem processes. Widely used models of dead-tree (snag) and down-log dynamics developed more than 35 years ago for the Blue Mountains (Maser et al. 1979, Thomas et al. 1979) are not fully compatible with ecology of dry-forest disturbance regimes.

Thomas et al. (1979) snag model portrays snags as going through nine stages of decay corresponding to the length of time a dead tree has been standing, eventually culminating in 'snag mortality' when a snag falls. Fallen snags then become downed logs, which go through another series of five classes of decomposition and decay (Maser et al. 1979) (fig. 26).

Frequent fires on dry-forest sites tended to burn snags before they could progress through all stages of a Thomas et al. (1979) snag model (Agee 2002a). The few fallen snags that did become downed logs also did not progress through all stages of a Maser et al. (1979) model because they typically burned when in decomposition class 1 or 2, seldom avoiding fire long enough to reach class 5 (fig. 26).

For a dry-forest climatic zone of the interior Pacific Northwest, a short-interval fire regime functioned as a primary wood and nutrient cycling process because microbial decomposition was too slow on these arid environments to keep pace with woody biomass accumulation (fig. 8 explains nutrient cycling differences between dry and moist forest sites).

When evaluated through a prism of ecosystem adaptation, dry mixed-conifer forests had low down-wood potential because frequent fire consumed much of the system's biomass (Agee 2002a), leaving biomass that did accumulate as a persistent ecosystem component – large, old trees (see figs. 44-46). Due to evolutionary adaptations of dominant trees (thick bark and an elevated canopy), resilience of these ecosystems was high, even when considering the high frequency of low-severity surface fire as a disturbance process.

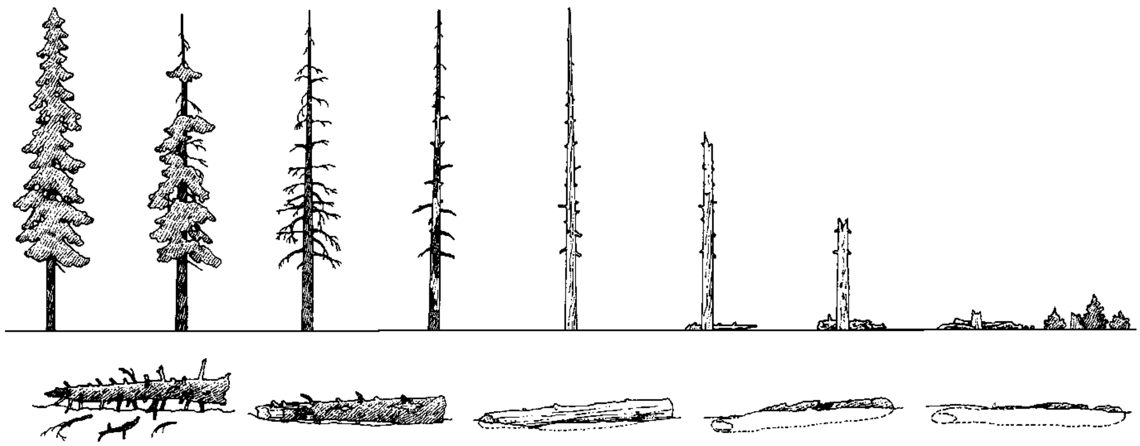


Figure 26 – Diagrams illustrating succession and evolution of snags (top) and down logs (bottom) through time (from Maser et al. 1979 and Thomas et al. 1979). These models of snag and down wood succession are most appropriate for ecological environments where decomposition is primarily accomplished by microbes (e.g., moist and cold upland forests; see fig. 8). They are probably less appropriate for dry-forest environments where woody detritus was cycled mainly by frequent surface fire (Passovoy and Fulé 2006, Stephens and Moghaddas 2005). Note that for dry sites, surface fire functioned ecologically as a coarse filter for both snags and logs (Agee 2002a).

What would happen if prescribed fire, rather than thinning, was applied to contemporary dry-site forests? In general, the outcome would be undesirable whenever a cohort of post-fire-exclusion trees is present (Bonnicksen 2000b). This post-exclusion cohort serves as ladder fuel (fig. 27), allowing a low-intensity surface fire to climb into upper canopy layers and kill dominant trees, including fire-resistant species (Arno et al. 1997, Steele et al. 1986).

When large quantities of standing dead trees are present following lethal fire on dry sites, salvage harvest is appropriate to remove some portion of this uncharacteristic fuel loading (Harvey et al. 1999, Mutch et al. 1993). [Despite controversy surrounding post-fire salvage harvest (Beschta et al. 2004), I assert that if a dry forest's live-tree density is uncharacteristically high, and if it burns with uncharacteristic fire severity, then resulting dead-tree density is also uncharacteristic, and salvage harvest could be used to reduce the number of dead trees to characteristic levels by retaining large-diameter, pre-fire-exclusion trees (see Brown et al. 2003 for post-fire fuel levels). What was uncharacteristic when alive does not automatically become characteristic when dead. "An over-abundance of green trees before a fire becomes an over-abundance of burned logs and snags ready to fuel the next fire" (Everett et al. 1996, p. 272).]

7.6 Restoration Alternatives

To be healthy, trees need a place in the sun and some soil to call their own (Society of American Foresters 1981). When crowded by too many neighbors, trees may not have enough soil and sun to maintain high vigor. Trees die after their vigor drops so low they can no longer heal injuries, resist attack by insects and diseases (by producing phenols, monoterpenes and other terpenoid resins, and similar defensive chemicals), or otherwise sustain life (fig. 28; Christiansen et al. 1987, Franklin et al. 1987, Kelsey 2001, Kolb et al. 1998, Langenheim 1990, McDowell et al. 2007, Nebeker et al. 1995, Peet and Christensen 1987, Wallin et al. 2008, Waring 1987).

Figure 27 – Shade-tolerant trees can get established on dry sites in an absence of surface fire (from Powell 1994). Grand firs and Douglas-firs are clustered around the base of a ponderosa pine in this image. Eighty or more years of fire exclusion promoted this successional progression on millions of acres in western North America (Schmidt et al. 2002). If selective harvest removes overstory trees, a multi-layered stand of late-seral species remains, and most of them are highly susceptible to drought and damage from defoliating insects (Wickman 1992). On dry sites where grand fir or Douglas-fir is climax, prescribed fire is effective for managing ingrowth of late-seral species (Kalabokidis and Omi 1998). A mound of bark flakes at the base of this old pine is an indicator of long-term fire exclusion; fire can smolder there and kill fine roots (Ryan and Frandsen 1991, Swezy and Agee 1991). Note: Experience in American southwest suggests it requires at least 100 years for ponderosa pine to develop a characteristic orange, platy bark shown here (White 1985).

Once a forest stand occupies its growing space, intertree competition causes some trees to die, and survivors immediately claim growing space relinquished by their dead neighbors. In nature, this self-thinning process eventually results in relatively few large trees occupying growing space that originally supported many small trees (Long and Smith 1984).

Land managers can emulate a natural competition process by intentionally reducing number of trees on a site, a practice called thinning. Thinning has been used to describe activities ranging from light removal of small understory trees to moderate removal of large overstory trees. On dry-forest sites where thinning is designed to emulate surface fire (Perera et al. 2004), a reference to thinning is assumed to be "understory thinning, thinning from below, or low thinning," which refer to cutting or removal of subordinate trees (fig. 29; Smith et al. 1997). To capture maximum restoration benefit from thinning, post-thinning stand density should be reduced to a lower limit of the management zone stocking level (figs. 30-31).

Critics of active management often characterize thinning as a silvicultural practice designed for commodity wood (timber) production, rather than acknowledging what it truly is – *application of a restoration tool in proper places and at appropriate times to achieve specific land management objectives through active management*. One contemporary objective is to create fire-safe forest conditions, particularly for developed areas containing wildland-urban interface or other values-at-risk, and thinning addresses three of four fire-safe principles (table 6).

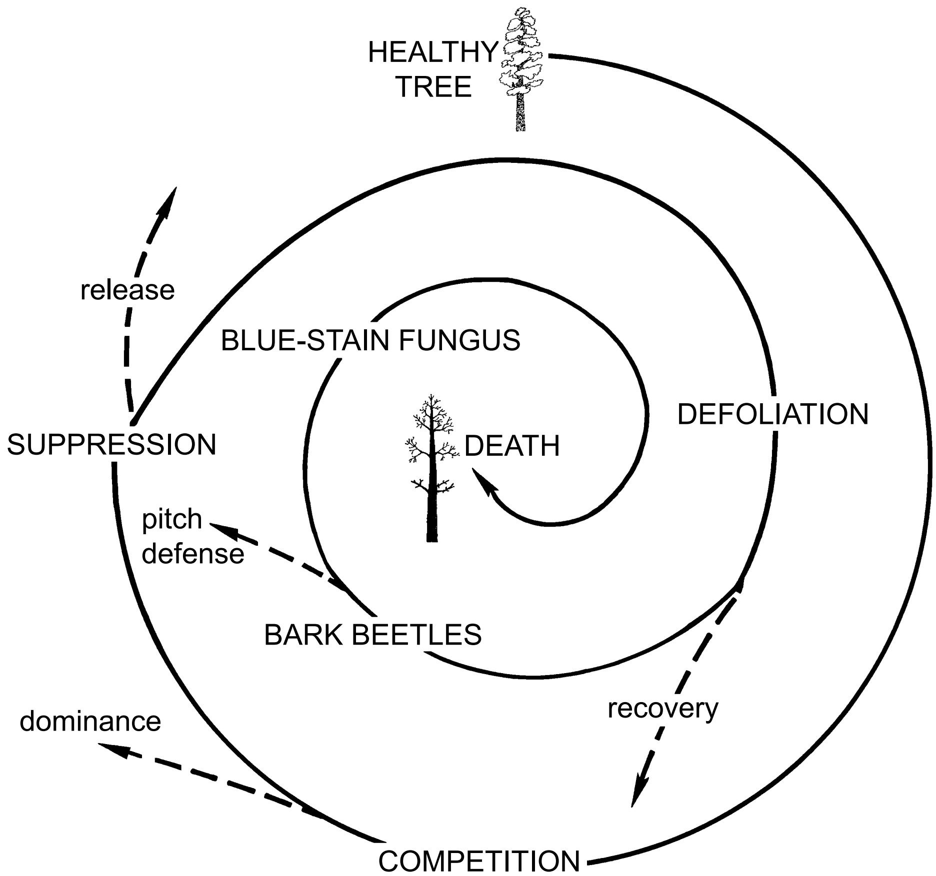


Figure 28 – Death spiral for a Douglas-fir tree in Blue Mountains (adapted from Franklin et al. 1987). In this death spiral, a slightly taller tree suppresses a shorter but otherwise healthy tree. If not released from competition, a suppressed tree is predisposed to attack by defoliators. Once partially defoliated, a weakened tree is attractive to bark beetles, including Douglas-fir beetles (Wickman 1978) carrying blue-stain fungus. Blue-stain fungus blocks water and sap movement and causes foliage desiccation. In this model of tree decline, suppression is a *predisposing* stressor; bark beetles and defoliation function as culminating or *inciting* stressors (Pedersen 1998).

Section 6 describes how selective cutting was one of three important factors contributing to dry-forest deterioration (the other two are fire exclusion and ungulate herbivory). Selective cutting, however, must not be confused with thinning. Not only are these activities implemented in different ways, but selective cutting was directed at short-term (economic) objectives (Ames 1931), while thinning is designed to meet silvicultural objectives. These differences demonstrate that all mechanical treatments are not the same – low thinning is an ideal restoration activity for dry forests, whereas selective cutting contributed to deterioration in the first place.

By removing some trees and increasing space around those that remain, thinning provides more sunlight, water, and nutrients for residual trees. Reducing tree density quickly improves physiological vigor of residual trees. High-vigor trees produce more resin and defensive chemicals than low-vigor trees, allowing them to better repel insect and disease attacks (Christiansen et al. 1987; Feeney et al. 1998; Kolb et al. 1998b; McDowell et al. 2003, 2007; Mitchell et al. 1983; Perrakis et al. 2011; Stoszek 1988; Vité 1961; Waring and Pitman 1985).

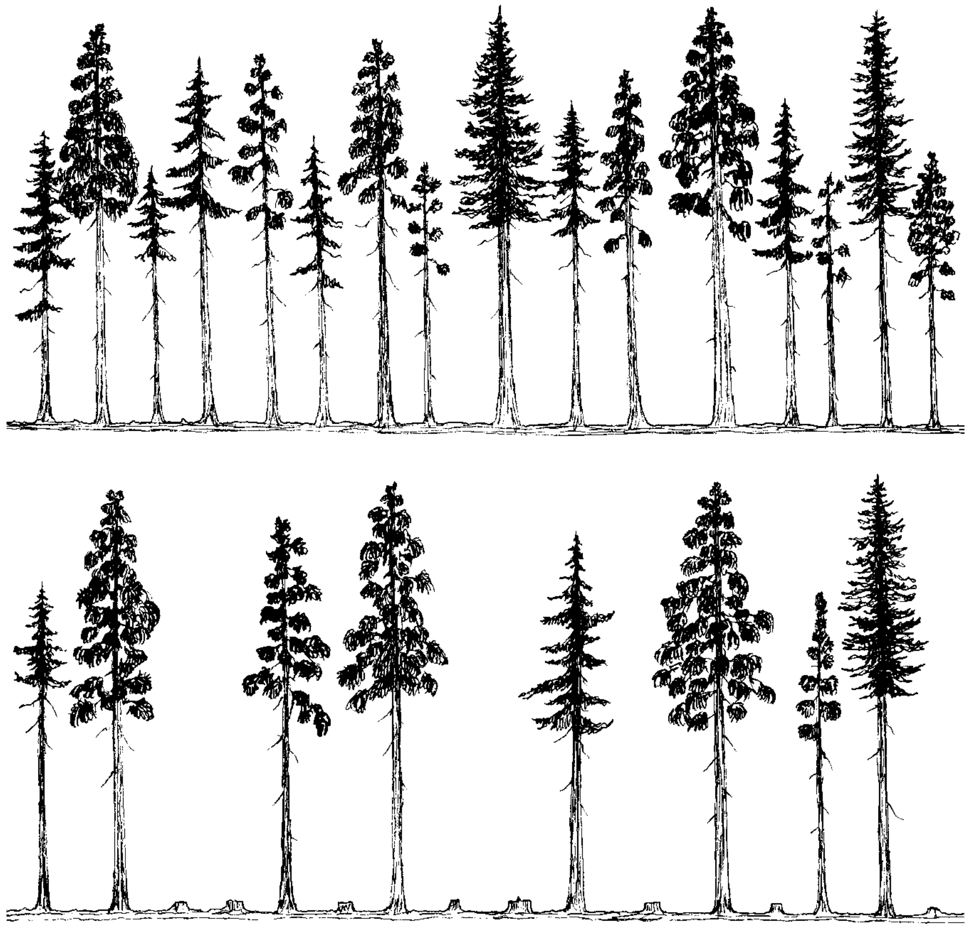


Figure 29 – Example of low thinning in a mixed-conifer forest (from Powell 1999b). Low thinning is defined as removal of trees from lower crown classes or canopy layers in order to favor trees in upper crown classes or layers. Low thinning is also referred to as 'thinning from below.' Note how smaller trees were removed in every instance but one: a western larch at center of top panel was infected with dwarf mistletoe to an extent threatening its continued survival. Because of its canopy position, the larch would not have been removed except for insect or disease reasons.

To capitalize on its forest health benefits, thinning was emphasized in Oregon Governor John Kitzhaber's strategy for restoring eastern Oregon forests, watersheds, and communities: "Understory thinning of green trees to restore forests to a healthy condition more representative of historic conditions is an important component of active management for forest health" (Kitzhaber et al. 2001).

"The silvicultural practices designed to maintain forest health will be different than those used to produce timber as a primary objective. Smaller material will be removed. There will be more use of thinnings, salvage, and other silvicultural treatments that involve removal of only a portion of the trees on a site. Wood product values will be lower and logging costs higher" (MacCleery 1995). A similar conclusion was reached during an assessment of timber availability from forest restoration in the Blue Mountains of Oregon, when it was noted that thinning might be difficult to accomplish economically due to small tree size (Rainville et al. 2008, p. 63).

Table 6: Principles of fire-safe forests.

PRINCIPLE	EFFECT	ADVANTAGE	CONCERNS
Reduce surface fuels	Reduces potential flame length	Fire control is easier; less torching of individual trees	Soil disturbance: less with prescribed burning, more with certain mechanical treatments
Increase height to live crown	Requires longer flame length to begin torching	Less torching of individual trees	Opens understory, possibly allowing surface winds to increase
Decrease canopy bulk density (foliage biomass)	Makes tree-to-tree crown fire spread less likely	Reduces crown fire potential	Surface winds may increase; surface fuels may become drier
Favor fire-tolerant tree species	Reduces potential tree mortality	Improves vegetation tolerance to low- and mixed-severity fire	If used too broadly, it could simplify composition at a landscape scale

Sources: Adapted from Agee et al. (2000) and Agee (2002b).

When comparing mechanical thinning and prescribed fire as active restoration treatments for dry-forest sites, mechanical thinning offers several advantages:

(1) It provides the most control over species composition, vertical structure, tree density, and spatial pattern for residual trees;
(2) It provides more control over amounts and distribution of standing and down wood as wildlife habitat (Tiedemann et al. 2000);
(3) It is not constrained to short, unpredictable weather windows like prescribed fire; and
(4) It may produce economically valuable wood products that could help defray restoration treatment costs (Barbour et al. 2007).

Guidelines have been developed to identify and describe site-specific levels of intertree competition (stocking), and to relate them to various categories of insect or disease susceptibility (Cochran et al. 1994; Hessburg et al. 1994, 1999a; Lehmkuhl et al. 1994; Powell 1999b; Schmitt and Powell 2005, 2012). These guidelines are commonly used to prepare silvicultural prescriptions for commercial thinnings and other density management treatments in dry forests. A basic density-management concept is this: maintain stands within an ecologically appropriate 'management zone' (fig. 30) to ensure reasonable stand development, high tree vigor, and improved resilience to a wide variety of insect and disease organisms.

Management Note: Unless management objectives dictate a different density management regime, *I suggest that a thinning treatment be initiated when stand density approaches an upper limit of a management zone (which is about 60% of maximum density or 75% of full stocking), and that thinning reduce stand density to a lower limit of a management zone (which is about 35% of maximum density or 50% of full stocking).* Figure 32 provides stocking charts portraying four density-management thresholds (fig. 32a) and two crown-fire susceptibility thresholds (fig. 32b), along with an example of how a stocking chart can be used to compare pre-treatment and post-treatment conditions (fig. 32c).

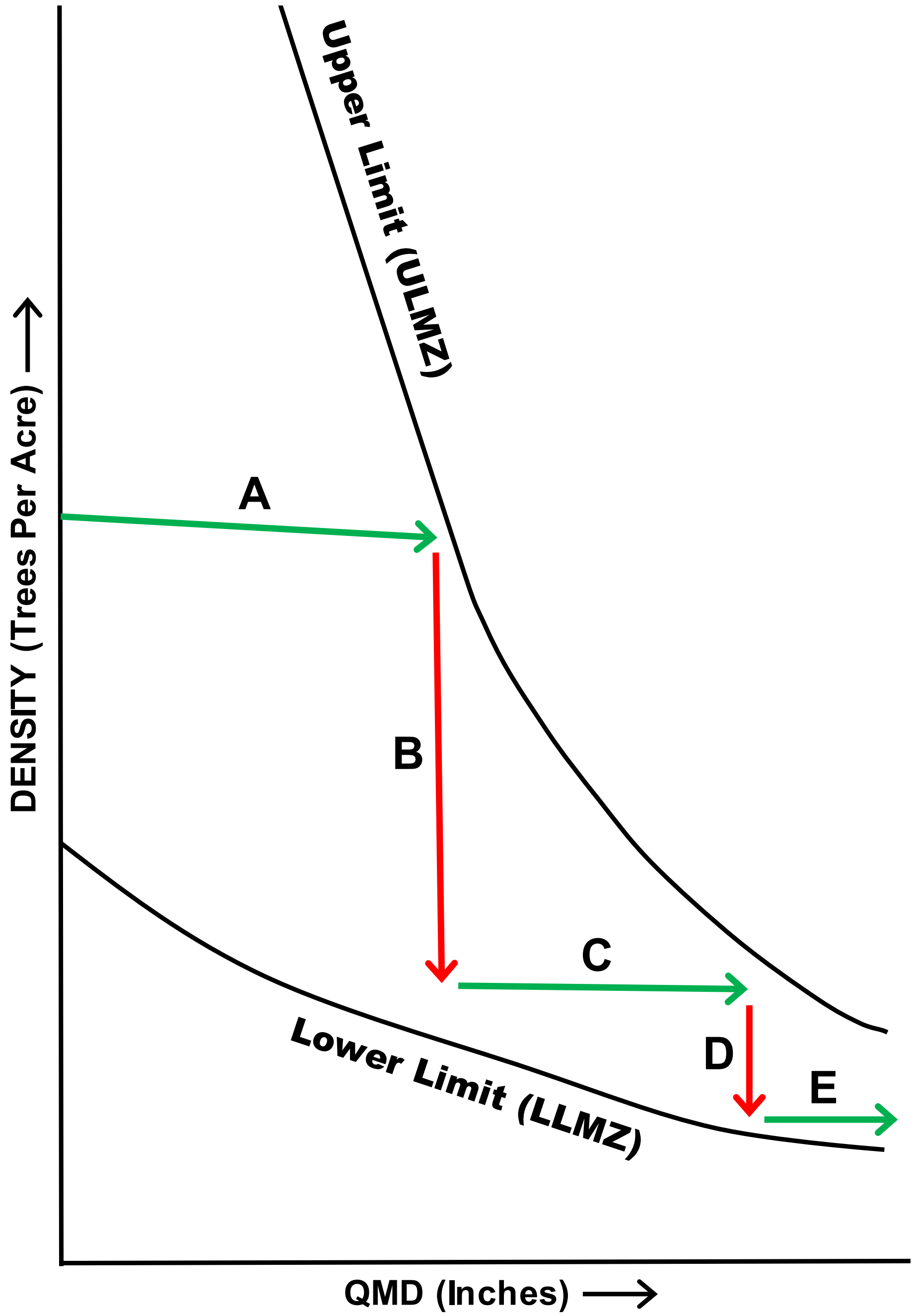


Figure 30 - Hypothetical thinning regime utilizing upper and lower limits of a management zone as stocking curves (curving black lines). This figure shows how a stocking-level chart could be used to prepare a thinning regime. In this example, initial stocking begins within a management zone and stand growth causes QMD to increase toward an upper limit (this is segment A; green segments show growth, and red segments show thinnings). When this example trajectory approaches an upper limit, thinning is completed and stocking is reduced until it approaches a lower limit (segment B). Post-thinning growth causes the stand to approach an upper limit again (segment C), at which point a second thinning is scheduled to reduce density toward the lower limit again (segment D). For this example regime, stand density would ostensibly be low enough to stay within a management zone after completing the second thinning (segment E).

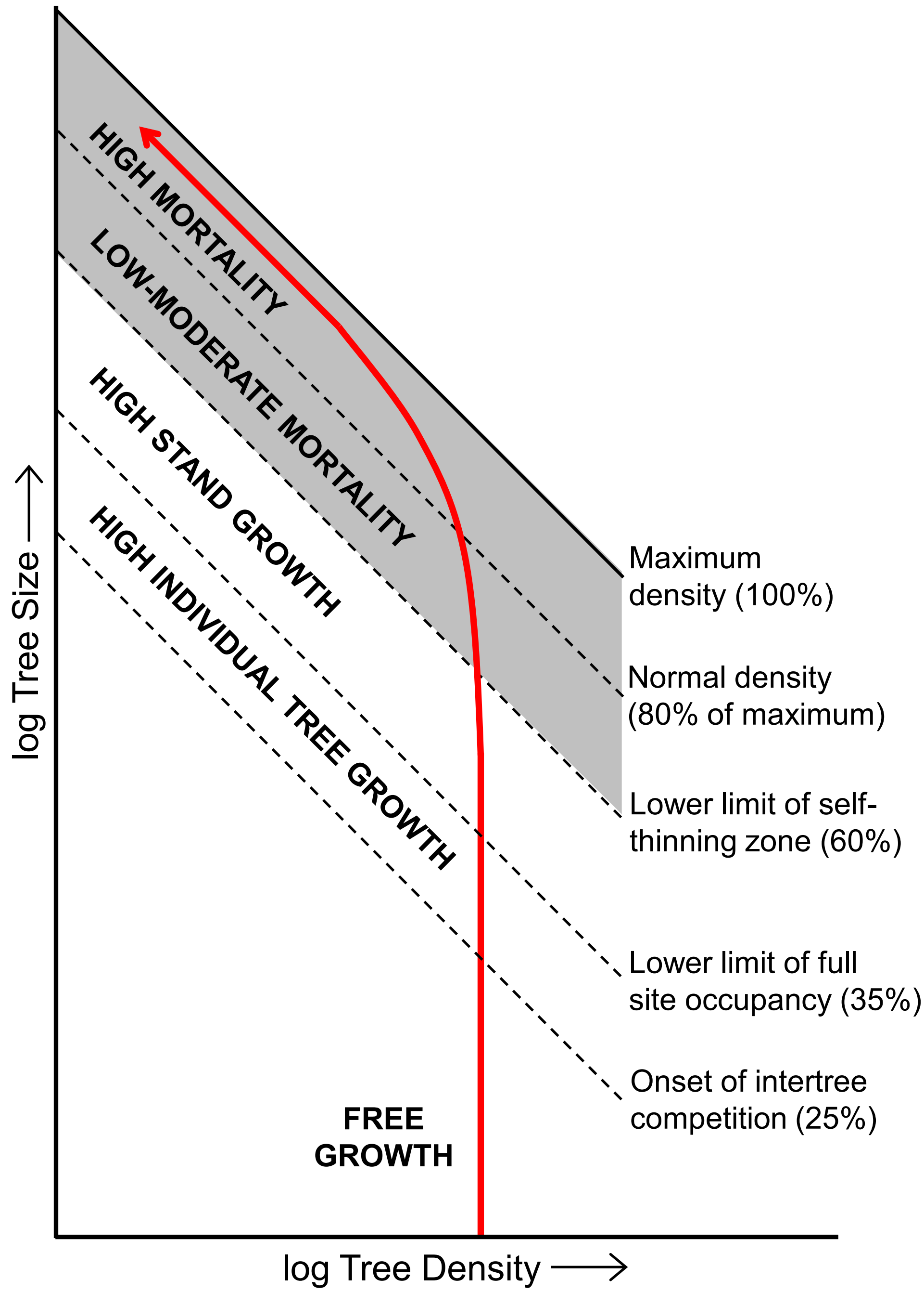


Figure 31 – Stand development indexed to maximum density. Initially, trees are too small to use all of a site's resources, and they experience a period of free growth (no intertree competition is occurring). Eventually, roots and crowns begin to interact and an 'onset of intertree competition' threshold is reached. As a stand continues growing through a zone of high individual tree growth, trees capture growing space and a 'lower limit of full site occupancy' threshold is breached. This next zone features high stand growth. As competition intensifies, stands eventually enter a self-thinning zone by crossing a 'lower limit of self-thinning zone' threshold. In a self-thinning zone (gray area), a tree can only increase in size if neighboring trees relinquish their growing space by dying. The pace of tree mortality quickens as a stand passes a 'normal density' threshold and approaches maximum density. Maximum density, shown as a solid line because it is an absolute threshold, is used as a reference level (100%) for the stocking system described here.

Selective cutting. A system in which groups of trees, or individual trees, are periodically removed from a forest as based on economic criteria aimed at maximizing commodity revenues, rather than trying to meet silvicultural objectives such as regeneration (Dunster and Dunster 1996) or stocking control.
Selection cutting. A regeneration cutting method designed to maintain and perpetuate a multi-aged structure by removing some trees in all size (age) classes, either singly (single-tree selection) or in groups (group selection) (Helms 1998). [Note: selective and selection cutting are quite different practices!]
Thinning. A treatment designed to reduce tree density and thereby improve growth of residual trees, enhance forest health, or recover potential mortality resulting from intertree competition. Two types of thinning are recognized – commercial thinning (trees being removed have economic value), and noncommercial thinning (trees are too small to have economic value, and usually left on-site) (Powell et al. 2001).
Prescribed fire. Deliberate burning of wildland fuels in either a natural or modified state, and under specified environmental conditions, in order to confine fire to a predetermined area, and to produce a fireline intensity and rate of spread meeting land management objectives (Powell et al. 2001).

Explanatory Notes for Figures 31-32, and Table 7. Figure 32 provides stocking-level tools for active management of dry upland forest. Figure 32 has three parts – conventional stocking levels expressed by using four stand density thresholds (fig. 32a); 'special-purpose' stocking levels expressed by using two levels of crown-fire susceptibility (fig. 32b); and an example of how stocking-level charts can be used to assess treatment effectiveness (fig. 32c). Figures 32a-32c assume an even-aged stand structure (e.g., SDI was not reduced to reflect an irregular or non-even-aged structure). Notes about threshold levels shown on the stocking charts (figs. 32a and 32b):

Maximum density: Although seldom observed in nature, maximum density can function as a useful upper limit, and it is often used as a 'reference level' when developing stocking levels.

Full stocking (80% of max): Full stocking is also referred to as normal density. Full stocking refers to single-cohort (even-aged) stands where intertree competition results in crown-class differentiation – dominant, codominant, intermediate, and subcanopy trees are found in differentiated stands. Normal density/full-stocking (fig. 31) occurs in a self-thinning zone where stand density is high enough to cause intense intertree competition and associated tree mortality.

Upper limit of a management zone (60% of max; Upper Limit in fig. 32a): This stocking level corresponds with a 'lower limit of self-thinning zone' threshold shown in figure 31. It is often used whenever land managers wish to avoid density levels high enough to cause self-thinning and competition-induced tree mortality.

Lower limit of a management zone (35% of max; Lower Limit in fig. 32a): This stocking level corresponds with a 'lower limit of full site occupancy' threshold shown in figure 31. This threshold functions well as a lower limit because a site is fully occupied at stocking levels above it – growing space is not being underutilized ('wasted') at these stocking levels.

High susceptibility to crown fire (High Susceptibility in fig. 32b): This stocking level pertains to stand densities where crown fire is easily sustained – namely, canopy fuel loading (bulk density or CBD) values of 0.10 kg/m^3 or more (Agee 1996c).

Low susceptibility to crown fire (Low Susceptibility in fig. 32b): This stocking level pertains to stand densities where crown fire is either impossible or highly unlikely – namely, canopy fuel loading (bulk density or CBD) values of 0.05 kg/m^3 or less (Alexander 1988, Van Wagner 1977).

CBD values (0.10 and 0.05 kg/m^3) for crown-fire susceptibility were translated into their corresponding forestry metrics (Powell 2010) in order to prepare a stocking chart (fig. 32b).

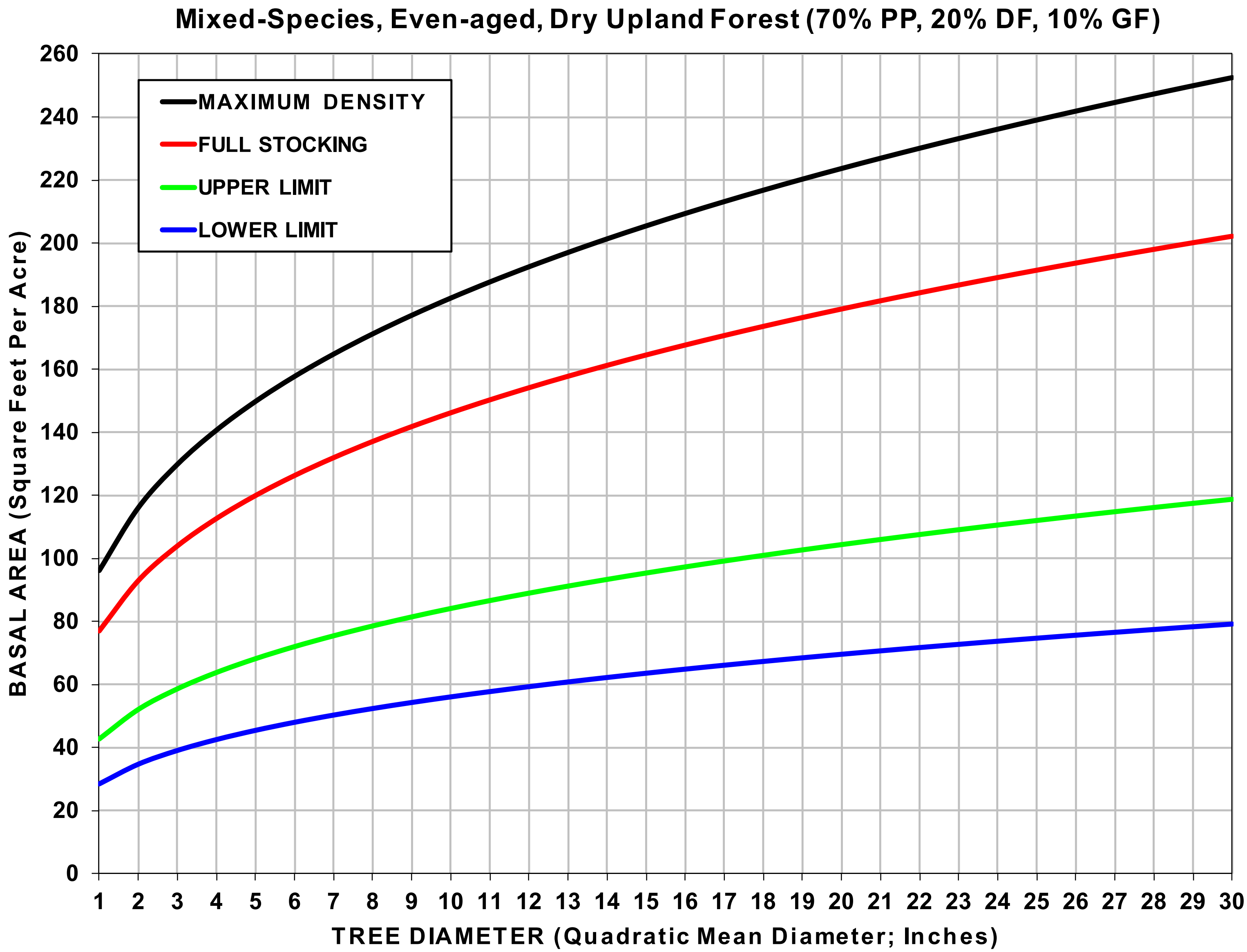


Figure 32a – Stocking chart for dry forests, expressing four stand density thresholds (color lines) by using basal area and QMD values.

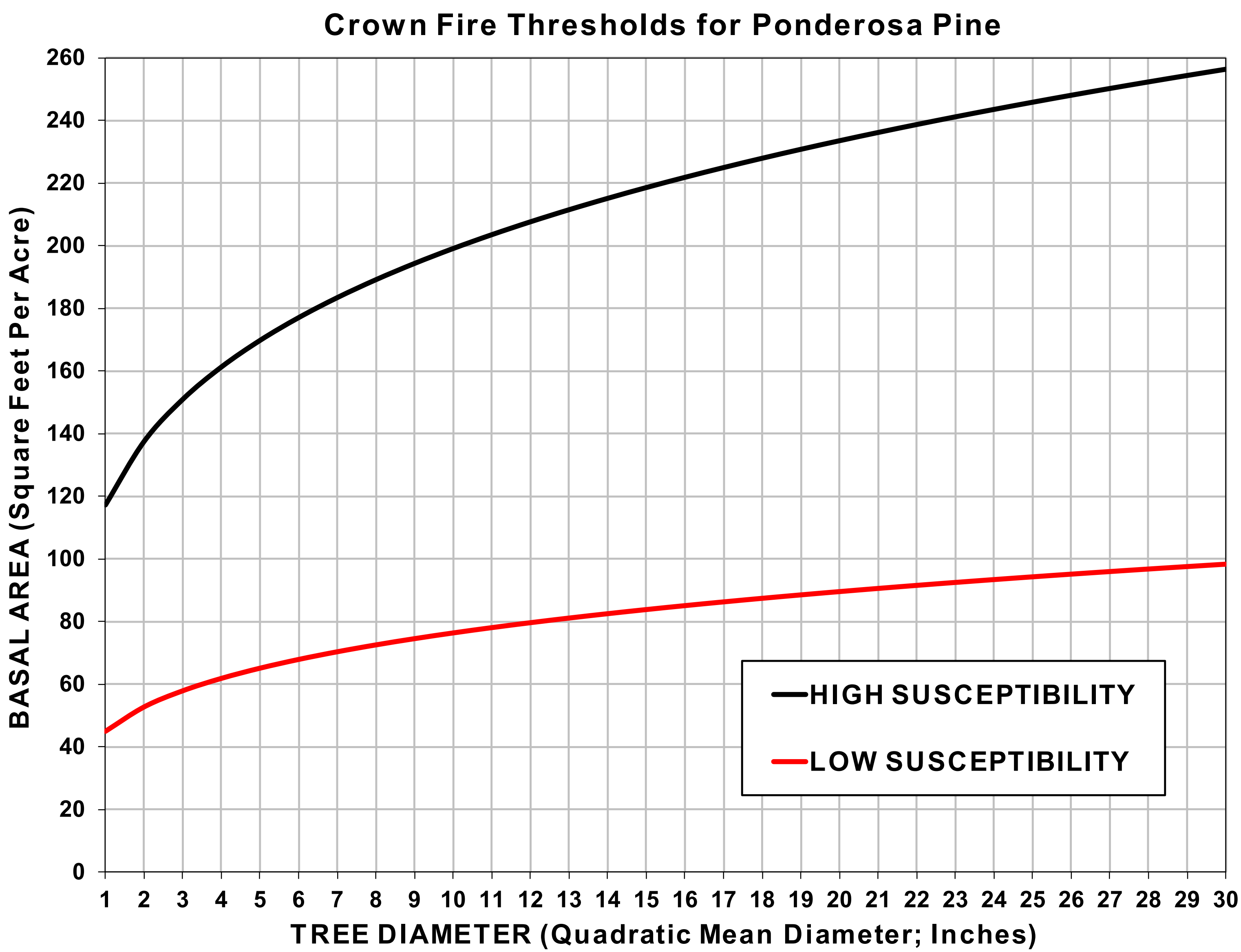


Figure 32b – Stocking chart for dry forests, showing two crown-fire susceptibility thresholds (color lines) by using basal area and QMD values.

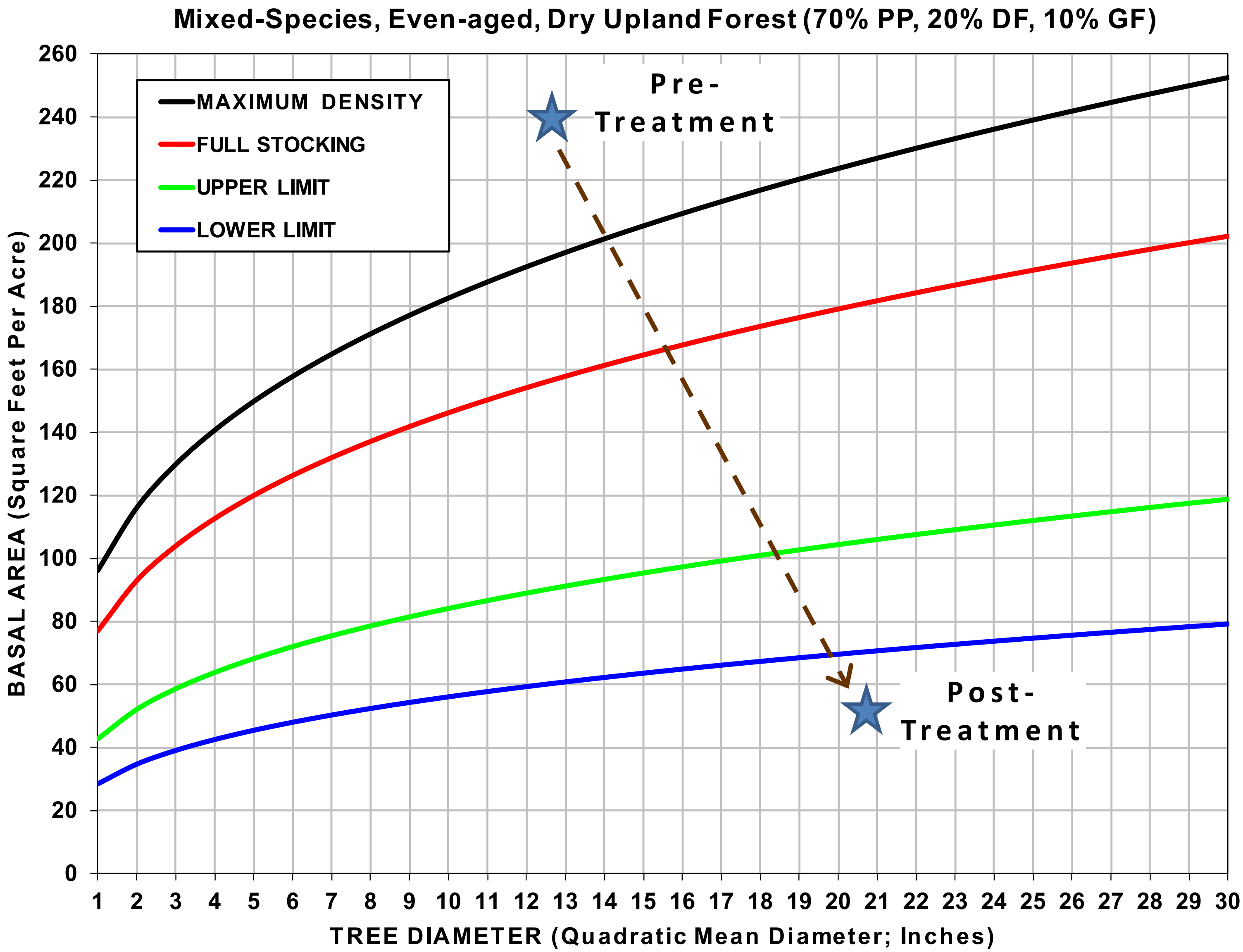


Figure 32c – Did a density-management treatment successfully move stand density within a management zone? In this example, treatment reduced stand density below a Lower Limit (pre-treatment = 238 ft^2/acre and 12.6" QMD; post-treatment = 50 ft^2/acre and 20.7" QMD).

Table 7: Recommended stocking levels for the dry-forest PVG, as expressed by using the stand development zones depicted in figure 30.

	CLIMATE CHANGE (WARMER, DRYER)		HIGH TREE GROWTH		HIGH STAND GROWTH		LOW-MODERATE MORTALITY		HIGH MORTALITY	
	0-25% OF MAX SDI		25-35% OF MAX SDI		35-60% OF MAX SDI		60-80% OF MAX SDI		80-100% OF MAX SDI	
	TPA	BAA	TPA	BAA	TPA	BAA	TPA	BAA	TPA	BAA
Ponderosa pine[1]	0-76	0-41	76	41	76-114	41-62	114-241	62-131	241-301	131-164
Douglas-fir	0-84	0-46	84-135	46-74	135-202	74-110	202-270	110-147	270-337	147-184
Western larch	0-80	0-44	80-128	44-70	128-192	70-105	192-256	105-140	256-320	140-175
Grand fir	0-142	0-77	142-226	77-123	226-340	123-185	340-453	185-247	453-566	247-309
Mixed composition[1]	0-84	0-46	84-103	46-56	103-154	56-84	154-268	84-146	268-335	146-183

Notes: Stocking levels are means for 24 plant associations assigned to a dry-forest potential vegetation group (PVG). They are expressed as percentages of maximum stand density index (SDI). TPA is trees per acre, and BAA is basal area (square feet) per acre; both metrics pertain to even-aged stands. Stocking levels presented in this table should be reduced by 7% for an irregular structure, and by 13% for an uneven-aged structure (and note that either of these structures is more common on dry-forest sites than an even-aged structure). TPA and BAA stocking levels pertain to a 10-inch quadratic mean diameter (QMD) – they will differ for a QMD other than 10 inches.

[1] For ponderosa pine, upper limits of 'high tree growth' and 'high stand growth' zones are calculated by using a process accounting for mountain pine beetle susceptibility (see Cochran et al. 1994), so they are not 35% and 60% of the mean maximum density SDI value for ponderosa pine (301). For mixed composition, stocking levels represent weighted averages (70% ponderosa pine, 20% Douglas-fir, and 10% grand fir).

Stocking-level categories, as depicted by using differing colors for column headings, have the following interpretations.

- 'Climate change' category is equivalent to 'free growth' zone in figure 31. Climate change research suggests the western United States could become significantly warmer and dryer as climate change continues, so climate-change stocking levels are lower than conventional levels shown to the right of them. (White paper #45, "Climate change and carbon sequestration," discusses climate change in more detail.)
- 'High tree growth' zone spans 25 to 35 percent of maximum density. A 25% value corresponds to 'onset of intertree competition' stocking threshold; a 35% value is 'lower limit of full site occupancy' threshold (fig. 31). For the Blue Mountains, 'lower limit of full site occupancy' threshold is traditionally used as the 'lower limit of a management zone' (see fig. 30) (Cochran et al. 1994, Powell 1999b).
- 'High stand growth' zone spans 35 to 60 percent of maximum density. A 60% value corresponds to 'lower limit of self-thinning zone' stocking threshold shown in figure 31. It is often used as the 'upper limit of a management zone' (see fig. 30) (Cochran et al. 1994, Powell 1999b).
- 'Low-moderate mortality' zone spans 60 to 80 percent of maximum density; this zone is lower half of a self-thinning zone depicted with gray shading in figure 31. An 80% value, app. midpoint of self-thinning zone, corresponds to 'normal density' stocking threshold shown in figure 31.
- 'High mortality' zone spans 80 to 100 percent of maximum density. A 100% value corresponds to maximum density shown in figure 31.

Regardless of whether mechanical thinning or prescribed fire is used as a forest restoration activity, fuel treatments need to account for wildlife needs. For example, research found that treated stands provide better elk forage during spring, whereas untreated stands provide better summer forage, suggesting that a mosaic of treated and untreated areas may provide better elk foraging habitat than treating a large proportion of a landscape (Long et al. 2008).

White-headed woodpecker, however, prefers lower- and mid-elevation ponderosa pine forests on flat or gently sloping terrain. Two features of dry forest are important for this species: availability of snags or cavity trees for nesting, and abundant ponderosa pine cones to provide seeds as a food source during winter (see Box 1) (Buchanan et al. 2003).

Restoration Considerations

Following stand-replacing fire on dry-forest sites, contentious debate about salvage harvest (Beschta et al. 2004, McIver and Starr 2000) almost always occurs, and it can distract decision makers from pressing issues of forest health and ecosystem restoration. But, some agreement exists among foresters, fire ecologists, and conservationists about eight potentially effective ways to expedite dry-forest restoration and postfire rehabilitation actions (Phillips 1995):

1. **Rethink local air-quality regulations, including 'nuisance smoke' ordinances.** This will allow more use of prescribed fire, while reducing pressure to extinguish natural fire ignitions that could be allowed to burn under prescribed conditions.
2. **Resolve liability issues** – fear of lawsuits over property damage from escaped prescribed fires prevents many forest managers from using this tool.
3. **Increase funding for hazardous fuels reduction.** National Fire Plan has an objective of reducing hazardous fuels, but funding for this type of work has not increased to a similar extent as it has for fire suppression activities.
4. **Determine extent to which environmental regulations are inhibiting forest restoration.** Legislation such as Endangered Species Act and National Environmental Policy Act have broad public support, but their implementing regulations could be modified to expedite fuel management and forest restoration treatments.
5. **Plan better for residential development in wildland-urban interface (WUI).** This is more of a political issue than a forest health issue, but presence of WUI (and other values at risk) increasingly affects how surrounding forests are managed (or not managed).
6. **Restrict herbivory in forestlands.** Domestic livestock grazing has been reduced from its early-1900s levels, but combined effects from domestic and wild ungulates contributes to replacement of some meadows and grasslands with woody, flammable vegetation.
7. **Create new markets for small-diameter trees from mechanical thinnings.** One option is to use federal revenues from tree harvest to help local communities develop technology for producing veneers, fiberboard, or cross-laminated timbers, or to use biomass material for producing ethanol, electricity, and thermal energy (LeVan-Green and Livingston 2001).
8. **Plan for landscape restoration.** Computer models, decision support systems, and visualization systems can be used to help balance public expectations for forest uses with a need to reestablish landscapes facilitating characteristic levels of fire, insect, or disease hazard. We must identify landscapes with highest priority for restoration treatments, and then seek to create a vegetation mosaic that functions within its historical range of variation.

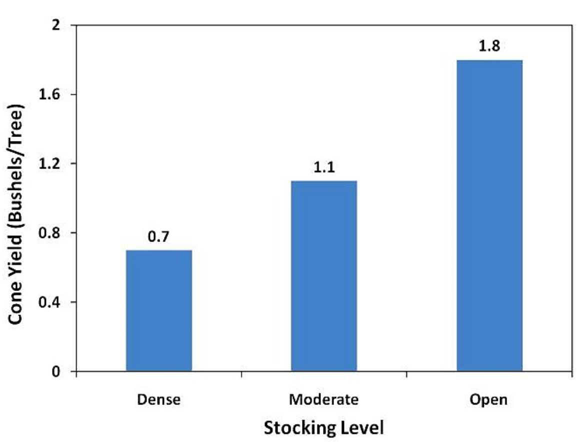
Box 1: Stand Density and White-Headed Woodpecker

This white paper describes how fire exclusion, ungulate herbivory, and selective timber harvest contributed to significant changes in dry-forest ecosystems. These changes resulted in a current emphasis on restoration of dry forests, not just for the Blue Mountains but throughout western North America. One restoration strategy involves reducing tree density to levels approximating a presettlement stand-density situation. Density reductions contribute to lower fire and insect susceptibility, rejuvenation of undergrowth plant abundance and species diversity, and improved wildlife habitat for species dependent on presettlement ponderosa pine forest conditions. One species of interest is the currently uncommon white-headed woodpecker (*Picoides albolarvatus*). In Oregon's portion of this woodpecker's west-wide range, ponderosa pine cones are believed to provide a primary food source during winter, non-breeding periods (Buchanan et al. 2003, Garrett et al. 1996).

Dry-forest restoration activities in Washington focusing on reintroduction of fire were apparently successful at increasing woodpecker abundance (Krannitz and Duralia 2004). Another restoration option is thinning, an active management practice believed to be especially applicable to white-headed woodpecker because it addresses the bird's winter food base by increasing cone and seed production (see chart below, showing cone yield by stocking level). Ponderosa pine cone production was observed to vary consistently with stand density in southwestern United States (Pearson 1912). "Since trees of larger diameter produce the majority of cones, increased cone production may be a longer-term benefit of thinning" (Krannitz and Duralia 2004).

It is also believed that an interaction between thinning and fire can increase cone production benefits of active management on dry sites: when wildfire occurred in a thinned stand in Arizona, and woody debris had been removed before it occurred, the fire improved resin production as compared with an unthinned control (Feeney et al. 1998). Similar results were reported in other studies (Kolb et al. 1998). Large-diameter ponderosa pine trees with increased capacity for producing resin and other defensive chemicals (Christiansen et al. 1987, Franklin et al. 1987, Kelsey 2001, Kolb et al. 1998, Langenheim 1990, McDowell et al. 2007, Nebeker et al. 1995, Peet and Christensen 1987, Waring 1987) are more likely to resist attack by western pine beetle, a primary bark beetle species known to prey on low-vigor, old-growth ponderosa pines.

Trees respond to thinning by producing more foliage and developing a higher level of photosynthate reserves, both of which improve their capability to resist and recover from insect or disease attack (Franceschi et al. 2005). A tree allocates photosynthate to its growth processes in an order of precedence: (1) maintenance respiration; (2) fine root and foliage production; (3) flower and seed production; (4) height, branch, and large-root growth; (5) diameter growth; and (6) insect and disease resistance. Since seed production and insect resistance rank fairly low in the hierarchy (#3 and #6, respectively), management practices can be used to sustain tree vigor at levels high enough to ensure that sufficient photosynthate is available to satisfy these physiological needs.



7.7 Restoring Old Forest On Dry Sites

In the interior Pacific Northwest, old forest structure occurs predominantly on two site types: dry sites and moist sites. Old forests were developed and maintained by differing disturbance regimes on these biophysical environments (Camp et al. 1997, Everett et al. 1994, Habeck 1990, O'Hara et al. 1996, Oliver and Larson 1996).

Old growth. Forest stands distinguished by old trees and related structural attributes such as tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function (Newton 2007).
Old forest. A structural stage characterized by a predominance of large trees (> 21" dbh) in a forest having either one or multiple canopy layers. On warm dry sites historically influenced by frequent surface fire, a single tree stratum may be present. On cool moist sites without frequent surface fire, multi-layer stands with large trees in an uppermost stratum are typically found.
Restoration. Holistic action taken to modify an ecosystem to achieve desired, healthy, and functioning conditions and processes. Generally refers to a process of enabling a system to resume acting, or continue to act, following disturbance as if disturbance had not occurred (Powell et al. 2001).

On dry mixed-conifer sites, frequent surface fires historically interrupted plant succession toward a climatic climax, thereby preventing eventual domination by Douglas-fir or grand fir. This short-interval fire regime maintained an early-seral species composition consisting of ponderosa pine (fig. 33); these stands were stable and resilient because ecosystems shaped by frequent disturbance exhibit a relatively narrow range of plant communities (Steele and Geier-Hayes 1995). An old forest structure produced by frequent fire is termed old forest single stratum (table 8).

Because cyclic fire remained relatively constant on dry mixed-conifer sites, ponderosa pine forests came to depend on a particular fire frequency and intensity (Sloan 1998b). Fire frequency must be maintained at an appropriate periodicity if ponderosa pine is to persist, and this is a reason why fire frequency, and not occurrence, has so much ecological influence. Species composition remembers fire, but abundance (tree density) forgets (Allen and Wyleto 1983).

An historic condition on dry sites was old ponderosa pine trees occurring in a park-like, savanna setting (fig. 34). This park-like structure did not occupy an entire landscape; dry mixed-conifer forest communities also supported snags, fallen logs, mid-size blackjack pines, and small seedlings and saplings. All of these stand attributes were influenced and sculpted by fire (Agee 2002a; Cooper 1960, 1961; Harrod et al. 1999; Munger 1917; Woolsey 1911; White 1985).

Thinning to develop an old-forest structure on dry sites differs from thinning to maximize tree growth and timber production. The complex structure of old forests is a product of their variability. Variable-density thinning promotes complexity by (1) thinning to different densities across a range of patch sizes; (2) leaving some patches, or portions of patches, unthinned (skips); and (3) creating small gaps (up to ½ acre in size) in some areas (Armleder 1999, Churchill et al. 2013a). "Studies show that when variable-density thinning is used, thinned stands usually have better developed understories, higher shrub densities, a greater richness of understory plant species, and more plant cover than unthinned stands" (McDowell et al. 2003, Rapp 2002).

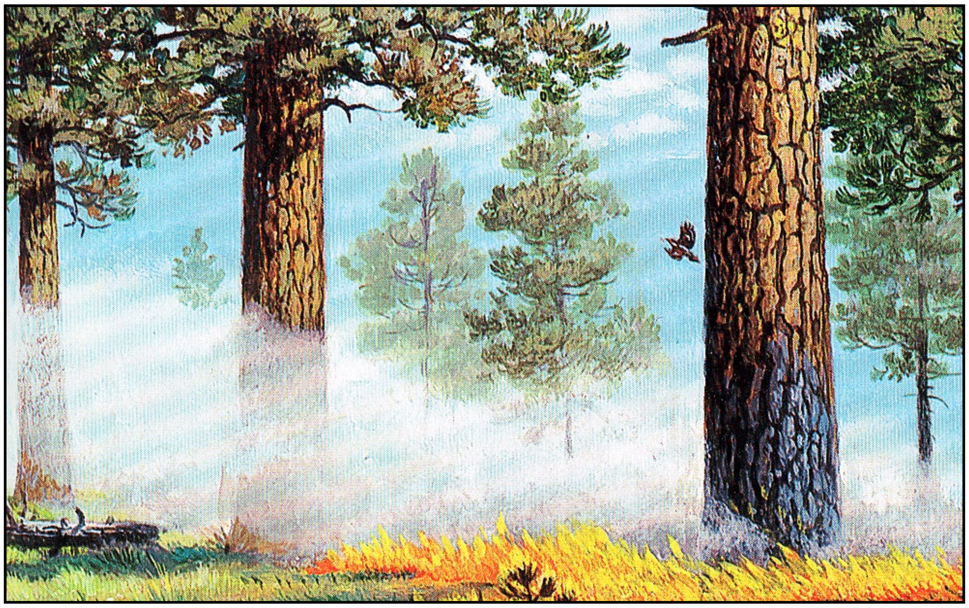
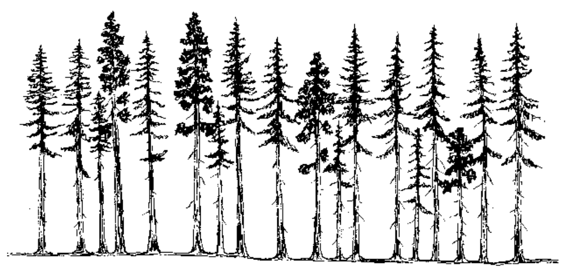
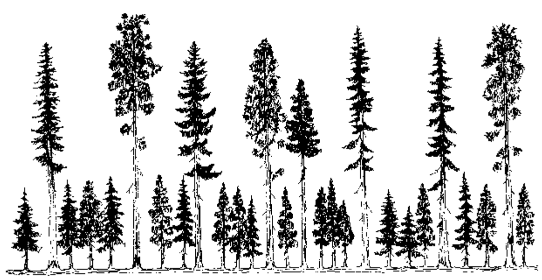


Figure 33 – Low severity surface fire in ponderosa pine forest (from Powell et al. 2001). In eastern Oregon, a presettlement fire regime created stable old forest referred to as 'park-like pine forest.' These ecosystems featured big, widely spaced ponderosa pines above a dense herb layer (also see fig. 5). This condition owed its stability to recurring visits by relatively benign wildfire every 5-20 years (Cooper 1960; Hall 1976, 1980; Munger 1917; Parfit 1996) (illustration by John D. Dawson, National Geographic Society).

Figure 34 – An open ponderosa pine stand with a grassy undergrowth (from Powell 1994). By suppressing low-severity, high-frequency surface fire, land managers were inadvertently swapping ponderosa pines for grand firs and Douglas-firs. This successional progression has important implications on susceptibility to defoliating insects such as Douglas-fir tussock moth and western spruce budworm because replacement tree species provide habitat for these insects (Mason and Wickman 1994, Wickman 1992).

Table 8: Description of forest structural stages.

	**Stand Initiation**. Following stand-replacing disturbance, growing space is occupied rapidly by vegetation that either survives a disturbance or colonizes an area. Survivors survive a disturbance above ground, or initiate new growth from underground organs or seeds present onsite. Colonizers disperse seed into disturbed areas, it germinates, and new seedlings establish. One stratum of tree seedlings and saplings is present in this stage.
	**Stem Exclusion**. Trees initially grow fast and occupy their growing space, competing strongly for sunlight and moisture. Because trees are tall and reduce light, understory plants are shaded and grow slowly. Species needing sunlight usually die; shrubs and herbs may go dormant. In this stage, establishment of new trees is precluded by a lack of sunlight (stem exclusion closed canopy) or by a lack of moisture (stem exclusion open canopy).
	**Understory Reinitiation**. A new tree cohort eventually gets established after overstory trees begin to die or because they no longer fully occupy their growing space. This period of overstory crown shyness occurs when tall trees abrade each other in the wind (Putz et al. 1984). Regrowth of understory vegetation occurs, trees begin stratifying into vertical layers, and a moderately dense overstory with small trees beneath is eventually produced.
	**Old Forest**. Many age classes and tree layers mark this stage featuring large, old trees. Snags and fallen trees may also be present, creating a discontinuous overstory canopy. The drawing shows single-layer ponderosa pine created by frequent surface fire on dry sites (old forest single stratum). Cold or moist sites, however, generally have multi-layer stands with large trees in an uppermost stratum (old forest multi strata).

Sources: Based on O'Hara et al. (1996), Oliver and Larson (1996), and Spies (1997).

Many land managers agree that fire exclusion was a policy with good intentions, but it failed to consider ecological implications of a major shift in species composition. Grand firs and Douglas-firs can get established under ponderosa pines when fire is absent, but they may not have enough resilience to make it over the long run, let alone survive the next drought. This means that many mixed-conifer stands that replaced ponderosa pine are destined to become weak, and weak forests are susceptible to insect outbreaks and disease epidemics.

Effects of the 1980s western spruce budworm outbreak (Powell 1994)

Principles Of Old Forest Restoration

I believe an old-forest restoration program for dry upland forests of the Blue Mountains should incorporate these concepts relating to landscape ecology of eastern Oregon (Camp et al. 1997, Everett et al. 1994):

- Current anomalous landscapes and disturbance regimes need to be restored to a more sustainable state if old-forest remnants are to be conserved, and old-forest networks created and maintained (Hessburg et al. 2005).
- Today, a mosaic of young forest types with heightened fire and insect hazard surrounds many old-forest remnants.
- An individual old-forest patch has limited landscape contribution, so additional old-forest stands must be continually created to maintain a dynamic old-forest equilibrium with time.
- Efforts to conserve old forest should not sacrifice contributions from other limited structures or components in a landscape.
- Conserving disturbance processes influencing ecosystems is every bit as important as conserving individual plant and animal species or old forest structure – a lack of disturbance can be as threatening to biological diversity as excessive disturbance (Noss 1983).
- Management regimes for old-forest patches should be congruent with disturbance regimes characteristic of their associated landscape.
- Any plan to sustain old forests must also sustain the landscape of which they are a part (Hessburg et al. 2005).
- When managing old forests, a landscape perspective is needed that coordinates wildlife species requirements with ecological processes and other functional ecosystem attributes (see Box 1) (Hessburg et al. 2005).
- Forest ecosystems of interior Pacific Northwest exist in a constant cycle of change; it should be acknowledged that successional pathways for a certain proportion of forest stands will be interrupted by fire, windthrow, insect attack, or disease before they reach an old-forest condition.

Strategies And Tactics For Restoring Old Forest

An effective restoration strategy for old forests in dynamic landscapes of interior Pacific Northwest should incorporate these considerations (Camp et al. 1997, Everett et al. 1994):

- Conservation of remaining old-forest patches is a cornerstone of any management scheme, if for no other reason than it best maintains future options.
- Sites that do not have a full complement of old forest attributes, such as tree 'defect' as shown in figure 35, can partially function as old forest for any attributes that are present.
- Dry old-forest differs dramatically from west-side Douglas-fir/hemlock old-growth (see Franklin et al. 1981), and it should not be evaluated by using west-side criteria. Managers should not use moist or cold wildlife species (such as marten) as dry, old-forest indicators.
- In some parts of a landscape it may be necessary to designate areas of younger forest as old-forest management areas (stands having priority for old-forest development) in order to meet desired future objectives with respect to a structural-stage distribution.
- Silvicultural practices can be used to accelerate development of old-forest characteristics in

young stands, particularly regarding practices influencing regeneration density, stocking levels, or competing vegetation (Gottfried 1992, Spies et al. 1991).

- Research showed that tree growth increases rapidly after stand density levels are reduced (Barrett 1979; Seidel and Cochran 1981), suggesting that thinning will accelerate production of a large-tree component of old forest (Sullivan et al. 2001, Tappeiner et al. 1997).
- When identifying candidates for future 'old forest multi strata' stands (tables 8, 10) in landscapes containing dry forests, stands should be selected with the highest survival potential to an old forest condition – specifically areas on north-facing aspects and at high elevations, particularly if they also occur within valley bottoms and drainage headwalls because these physiographic positions function as semi-stable environmental settings (Camp et al. 1997).
- Although mid- to late-seral stands are 'in a pipeline' to replace old forests lost to disturbance, we still do not know an appropriate ratio of late-seral to old forest patches to ensure that desired levels of old forest are maintained in perpetuity (but see section 7.9, RV).
- Evaluating historical amounts of old forest (as is done when analyzing a range of variation for forest structural stages: table 10) provides a first approximation for how much old forest was sustainable and in which old-forest-dependent plant and animal species evolved.
- Ideally, historical evaluations should incorporate several reference points in time, and at sufficient spatial scales, to ensure that spatial and temporal disturbance regime characteristics have been accounted for.
- A successful strategy would allow flexibility in specific on-the-ground locations over time. A 'shifting mosaic' landscape concept (Clark 1991) suggests a dynamic framework in which old forest patches are lost and created at appropriate spatial and temporal scales.
- Old forest restoration carries long-term management costs with little expectation of substantial commodity production. Creation of an old-forest network explicitly assumes that biological diversity and other old-forest objectives are supported socially and economically.
- A dynamic ecosystems philosophy should be a foundation of an old-forest strategy – an ecologically sustainable representation of old forest structure in a landscape is more important than perpetuation of old forest patches in a specific location. Old-growth should be perceived as a dynamic entity influenced primarily by fine-scale mortality and recruitment.
- Research suggests that light fuel treatment across a portion of a landscape provides considerable reduction in overall landscape fire risk, although it may not lower risk for individual reserves containing large trees and multi-layered canopies (Wilson and Baker 1998).
- Efforts to protect individual old-forest stands through moderate or intense management of adjoining stands apparently provides minimal reductions in fire risk, although reducing surface fuels by using a combination of thinning and prescribed fire might provide at least a modicum of fire protection (Wilson and Baker 1998).
- Low thinning and prescribed fire in an old-forest stand will lower its fire risk substantially (Johnson et al. 2011, McIver et al. 2013); however, some of a stand's old-forest characteristics (such as multi-layered canopies) are altered by such practices (Wilson and Baker 1998).
- Thinning and prescribed fire can be especially valuable for sustaining high vigor levels for old ponderosa pines, and high vigor translates into increased resin production and chemical defenses against western pine beetles (fig. 36) and other bark beetles (Perrakis et al. 2011).

Figure 35 – Ponderosa pine 'character' tree on Pomeroy Ranger District of Umatilla National Forest. One focus of dry-forest restoration is to retain these character trees in recognition of their value to wildlife. Old character trees have distinctive ecological characteristics, including unusual shapes formed in response to both physical and biotic damage (wind, mechanical abrasion, disease, parasites, and insects). Note how an old fire scar at this tree's base is now decayed, providing habitat for cavity-dependent wildlife species. Contorted, upper-crown branches, horizontal crown branching, and multiple ('bayonet') tops are also indicative of this tree's wildlife value (Van Pelt 2008).

Figure 36 – Old ponderosa pine killed by western pine beetle. Journal articles emphasize the importance of restoring historically appropriate intrastand structure (Larson and Churchill 2012, Larson et al. 2012). A feature of historical, dry-forest structure is clumps of mature trees. Large trees in closely-spaced clumps are under enough stress to function as focus trees (Eckberg et al. 1994) for western pine beetle. Historically, large-tree clumps occurred in a vegetation mosaic where openings were common; a clump embedded in an herbaceous opening (savanna condition, as described in Munger 1917) experienced a much different competitive environment than a clump surrounded by trees.

Scale Considerations For Dry Forest

Scale is fundamentally important, and scale considerations permeate all aspects of active management (Cumming et al. 2013). For example, many recent journal papers from landscape ecology and forest management literature emphasize the importance of spatial heterogeneity (Franklin et al. 2008, 2013; Hessburg et al. 1999b, 1999c, 2000, 2004, 2007; Turner et al. 1989, 1994, 2001; and many others in References section).

When evaluating spatial heterogeneity for dry forests, it is important to consider a sub-stand level because scale is fine-grained and intricate for dry forests – ponderosa pine stands historically featured a groupy or clumpy structure at a sub-stand scale (Harrod et al. 1999; also see Powell 2019b). A stand functions as an 'aggregating' level because a consistent but repeating pattern of groups or clumps could be collected (aggregated) within a common stand boundary. In this context, sub-stand clumps function as a fine-scale, base-level unit, reflecting ecosystem pattern and process, but a stand functions as an aggregating unit (e.g., stands are a mid-scale unit representing aggregations of sub-stand clumps). [I define 'base-level' as a scale at which ecosystem processes result in tree regeneration sufficient to perpetuate a forest type.]

Note about clumps: Tree clusters are a feature of many forest ecosystem types. For dry forests, tree clusters can be created by a disturbance regime – variable thinning provided by surface fire, or pockets of tree regeneration after western pine beetle attack (see figures 44-46 later in this paper), in which case clusters function well as an indicator of ecosystem function and process. But we should consider that dry-forest clusters can also be caused by seed caching activity of deer mice, chipmunks, and other small mammals (Keyes et al. 2007).

Practitioners should be able to interpret spatial pattern in order to understand if it should be emulated by proposed treatments. Does pattern reflect inherent ecosystem process, in which case it would be repeatable across a landscape? Or, is it simply a product of random historical circumstances that may not be repeated again? Answers to these questions are important because contemporary science emphasizes provision of spatial heterogeneity, <u>but</u>:
It is most important to provide heterogeneity for biophysical environments where heterogeneity was a normal 'byproduct' of a properly functioning disturbance regime.

Scale's fundamental importance also provides a useful context for evaluating existing conditions of species composition, forest structure, and stand density. Compositional or structural changes need to be evaluated at a sub-stand scale for dry forest (e.g., at the scale of a tree clump or cluster) – Is a characteristic clumpy structure still evident for a dry forest stand? If so, does composition of any particular dry-forest stand feature a majority of ponderosa pine rather than fire-sensitive (late-seral) species such as grand fir?

Dry-forest composition could be evaluated this way: up to 70% of tree clumps in a dry-forest stand should have a predominance of ponderosa pines, rather than a majority of Douglas-fir or grand fir (because properly functioning surface fire produced high percentages of ponderosa).

Dry-forest conditions have changed dramatically as a result of fire exclusion, livestock grazing, and selective cutting – and these changes are overtly expressed in existing conditions, including at a clump scale, so when entering most dry-forest stands, it quickly becomes apparent when they are substantially departed from reference conditions (see page 46). *Unfortunately, we've taken an ecosystem sustained by fire, and converted it to one destroyed by fire*.

7.8 Active Restoration Of Dry Forests: Wildlife Considerations

A primary purpose of this white paper is to examine silvicultural considerations related to active management of dry-forest ecosystems. Dry-forest management is also influenced by wildlife concerns, and some of them are discussed in this section (Box 1 in section 7.6 also provides a wildlife discussion). An informative synthesis of fuel reduction and fire surrogate treatments was recently published, and because it provides an excellent summary of wildlife-silviculture interactions, I decided to include it here (Stephens et al. 2012b, p. 553-557). Note that any literature citations in quoted material below are also included in this white paper's References section. [A wildlife synthesis journal paper was recently published for moist, mixed-conifer forests (Irwin et al. 2018), and it also includes useful insights.]

"In addition to its use in managing wildfire hazards, the application of prescribed-fire and fire-surrogate treatments is frequently motivated by wildlife-habitat objectives (Yager et al. 2007, Kennedy and Fontaine 2009, Roberts et al. 2010). Research on fire and its effects on terrestrial vertebrates (wildlife) has been conducted since the early 1900s, beginning with research showing the negative effects of fire exclusion in longleaf pine (*Pinus palustris*) forests on northern bobwhite (*Colinus virginianus*; Stoddard 1931). Since then, a large body of work has been developed, particularly in the last 10-15 years (Kennedy and Fontaine 2009), which has shown that many wildlife species depend on fire-maintained habitats or pyrogenic structures, such as the snags, shrubs, and bare ground created by fires of varying severity (Hutto 2008).

Increased applications of fuel-reduction treatments, public scrutiny of land management agencies, and a growing scientific literature on the topic motivated a recent comprehensive review and meta-analysis of the fire-wildlife literature from forests dominated by low- to moderate-intensity fire regimes (Kennedy and Fontaine 2009, Fontaine and Kennedy 2012). On the basis of the characteristics of the available literature, fuel-reduction treatments and high-severity fire were considered at 0-4 years post-treatment. A lack of published longer-term (more than 5 years) studies precluded any analyses of longer-term effects. Importantly, the only thinning treatments included in this analysis were those conducted for fuel reduction, which is generally a lower-intensity treatment (e.g., the median reduction in basal area for the FFS Study was 30%; Schwilk et al. 2009) than those implemented for other silvicultural objectives (see Vanderwel et al. 2007 for a detailed meta-analysis of avian responses to a broad range of thinning intensities).

Data from low- and moderate-severity fires were pooled, because neither of these treatments resulted in a large canopy loss (less than 50% canopy mortality, less than 25% in almost all cases), and there are insufficient studies of mixed-severity fire to warrant separation. These categories allowed for a comparison of vertebrate responses (mean abundance, density, and vital rate in treated and reference conditions) to fire surrogates combined with fire, as well as differing levels of fire severity (measured by overstory tree mortality). Data were more abundant for birds than for any other taxon (fig. 37), which underscores a need for further work on other wildlife taxa – particularly herpetofauna, which reside primarily on the forest floor.

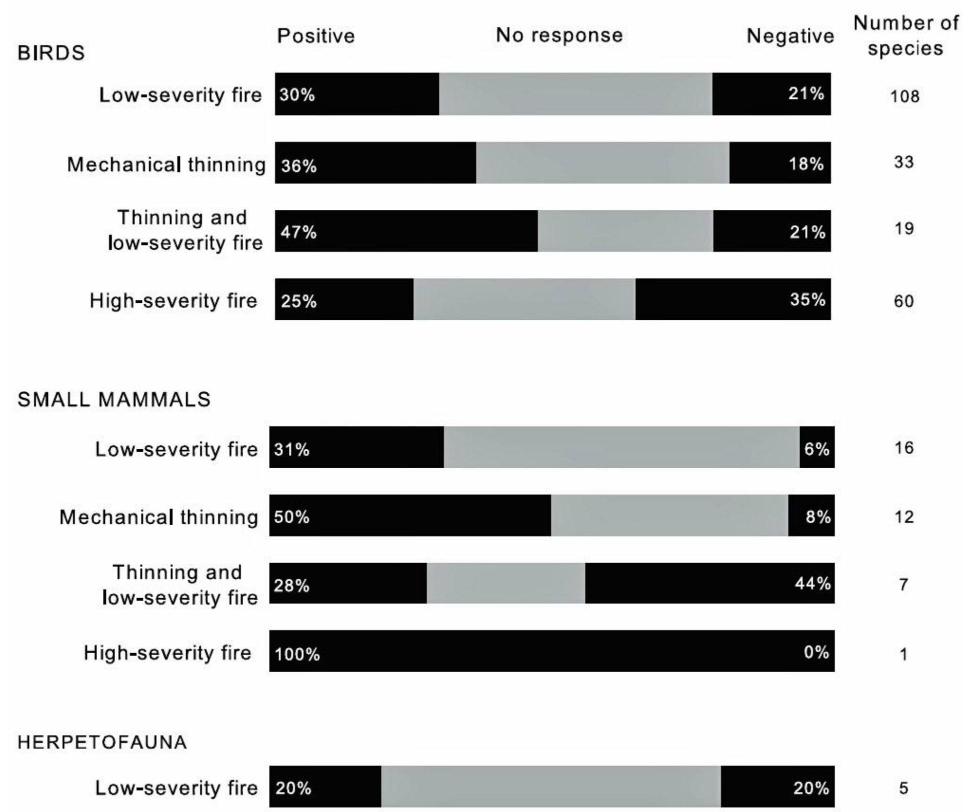


Figure 37 – The responses (positive, neutral, and negative; number of species with sufficient data) of birds, small mammals, and herpetofauna to fire and fire-surrogate treatments 0-4 years after fire treatment in seasonally dry forests of the United States (this is fig. 3 from Stephens et al. 2012b). The response classification was based on a meta-analysis of existing literature and generation of cumulative effect-size estimates and their 95% confidence intervals with overlap (neutral) or not (positive, negative) with zero.

This similarity in the responses of birds and small mammals to thinning and low-severity prescribed fire suggests that, at the stand scale and in the short term (0-4 years), thinning may adequately mimic low-severity fire in terms of its effects on these taxa. The levels of regeneration of vegetation, fuel dynamics, and nutrient cycling following prescribed fire and following thinning differed substantially (Boerner et al. 2009, Schwilk et al. 2009), but thinning or low-severity prescribed fire have the potential, in the short term, to create forests with similar structure and with habitat conditions favored by many wildlife species. Therefore, the results suggest that the use of thinning in lieu of prescribed fire may be warranted for birds and small mammals, particularly in areas in which the implementation of prescribed fire is problematic. However, the long-term effects of these two treatments on wildlife require further investigation before these results can be fully integrated into management.

Research illustrates that these fuel treatments do not create conditions suitable for all species (see negative responses in fig. 37). Additional analyses demonstrate that low- to moderate-severity surface fire (and presumably its thinning surrogate) does not mimic the early successional habitat conditions created by high-intensity, patchy, stand-replacing fires. When it is feasible, managers may aim for patchy high-intensity prescribed fire to mimic the effects of wildfire

(Fulé et al. 2004a). In short, there is no one-size-fits-all prescription when it comes to incorporating disturbances into land management (i.e., there is a need for the presence of all successional stages within a forested landscape to maximize wildlife diversity; Fontaine et al. 2009).

The wildlife literature, which is dominated by studies on birds and small mammals, demonstrates that in the short term and at the stand scale, fire-surrogate forest-thinning treatments effectively mimic low-severity fire, whereas low-severity fire is not a substitute for high-severity fire (Kennedy and Fontaine 2009)."

7.9 Range Of Variation As A Restoration Framework

Range of variation. A characterization of fluctuations in ecosystem conditions or processes over time; an analytical technique used to define bounds of ecosystem behavior that remain relatively consistent through time (Morgan et al. 1994). Values of an attribute, such as composition or structure, that occur within upper and lower bounds determined for an attribute (Jennings et al. 2003).

Range of variation (RV) is an analytical technique to characterize inherent variation in ecosystem composition, structure, and function, reflecting recent evolutionary history and dynamic interplay of biotic and abiotic factors (fig. 38). "Study of past ecosystem behavior can provide the framework for understanding the structure and behavior of contemporary ecosystems, and is the basis for predicting future conditions" (Morgan et al. 1994).

RV is meant to reflect ecosystem properties free from major influence by Euro-American humans, thereby providing an insight into ecosystem resilience (Kaufmann et al. 1994). It helps us understand what an ecosystem is capable of, how historical disturbance regimes functioned, and underlying variation in ecosystem processes and functions – patterns, connectivity, seral stages, and cover types produced by ecological processes operating at a landscape scale (USDA Forest Service 1997).

Perhaps an effective yardstick for evaluating health of dry forests is historical variation – are changes caused by insects, diseases, and wildfire consistent with what would be expected (the RV) for similar ecosystems and vegetative conditions? Since ecosystems are constantly changing, we need to assess their health by using a metric, like RV, that explicitly accounts for change. Resilient forests not only tolerate periodic disturbance, they depend on it for rejuvenation and renewal (Johnson et al. 1994). Obvious changes in disturbance magnitude (extent), intensity, or pattern, however, may be warning signals of impaired ecosystem integrity (Sampson and Adams 1994).

Range of variation concept has been proposed as a way to identify restoration needs and opportunities. Using reference conditions to guide restoration programs will continue into the future because this approach is explicitly required by certain laws governing dry-forest management, such as Healthy Forests Restoration Act: "In carrying out a covered project, the Secretary shall fully maintain, or contribute toward the restoration of the structure and composition of old growth stands according to the pre-fire suppression old growth conditions" (http://www.gpo.gov/fdsys/pkg/PLAW-108publ148/pdf/PLAW-108publ148.pdf).

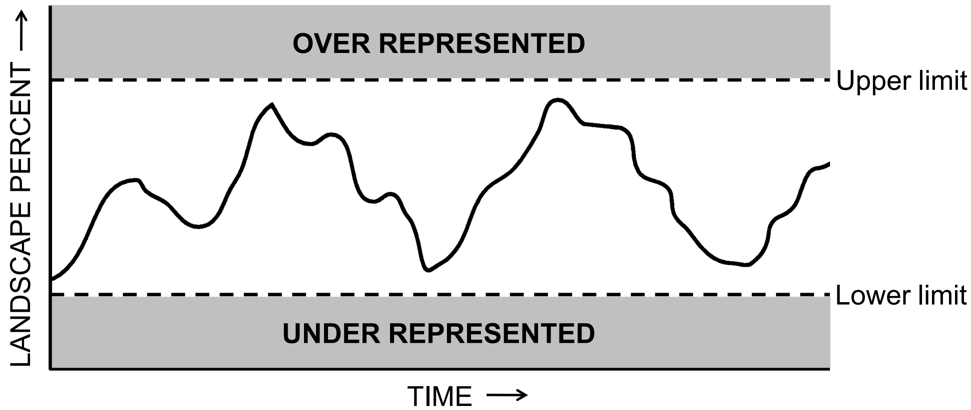


Figure 38 – A range of variation (RV) helps us decide whether existing amounts of vegetation composition, structure, and density, when summarized for a landscape-scale analysis area, are occurring within a characteristic range (Aplet and Keeton 1999, Morgan et al. 1994, Swanson et al. 1994). This diagram shows an ecological trajectory for an ecosystem component (the solid line); it varies through time because the phrase 'range of variation' is meant to encompass more than just extreme values (e.g., upper and lower limits, shown as dashed lines) (diagram modified from Morgan et al. 1994).

RV is a good example of a dynamic equilibrium concept because modal or central-tendency conditions obviously vary over time (shown by a squiggly solid line in center), and yet they vary within an equilibrium zone whose limits (two dashed lines) are defined by a range of potential ecological expressions. Note that conditions occurring above an upper limit are characterized as over-represented; conditions below a lower limit are under-represented (representation zones are depicted with gray shading).

Both now and in the future, a desirable landscape condition for Blue Mountains province is a diverse, heterogeneous vegetation mosaic more consistent with a range of variation, less susceptible to uncharacteristic disturbance events, and thus more sustainable (Mutch et al. 1993, Sampson et al. 1994). Using an RV approach to help restore vegetation diversity means providing a full spectrum of structural elements, in variable configurations and quantities, with an ultimate objective being maintenance of dynamic patterns and processes integral to resilient ecosystems (Aplet and Keeton 1999).

Dry-forest RV information for species composition, structural stage, tree density, and insect and disease susceptibility is provided in tables 9-12. Information in table 9 expresses percentages of a dry-forest landscape (preferably at least 15,000-35,000 acres in size) occupied by various vegetation cover types (ponderosa pine, grand fir, etc.). A cover-type patch (stand) may have a majority of one species – if grand fir comprises more than 50% of stocking, then cover type is coded as ABGR. If less than 50% of a species is predominant, however, then a cover type is named for a species comprising a plurality of stocking – if grand fir is less than 50% of stocking but it is predominant, then cover type is coded as mix-ABGR.

I must emphasize that cover type information in table 9 does NOT reflect species composition of an individual stand or polygon. In other words, species composition of a typical dry-forest stand would <u>not</u> be expected to consist of 50-80% ponderosa pine, 5-20% Douglas-fir, 1-10% grand fir, and so forth – these ranges, taken from table 9, refer to percentages of a dry-forest <u>landscape</u> supporting ponderosa pine stands, Douglas-fir stands, grand fir stands, etc.

Table 9: RV information for species composition (vegetation cover type) for dry upland forest PVG.

Vegetation Cover Type	Range of Variation (Percent)
Grass-forb	0-5
Shrub	0-5
Western juniper	0-5
Ponderosa pine	50-80
Douglas-fir	5-20
Western larch	1-10
Broadleaved trees	0-5
Lodgepole pine	NA
Western white pine	0-5
Grand fir	1-10
Whitebark pine	NA
Subalpine fir and spruce	NA

Sources/Notes: Derived from disturbance process modeling based on Vegetation Dynamics Development Tool (VDDT) (Powell 2019c). NA is Not Applicable.

Cover types reflect vegetation composition of a polygon (Eyre 1980, Shiflet 1994); they are described in Powell (2013a). Cover types consist of these coding combinations:
Grass-forb: all grass and forb codes;
Shrub: all shrub codes;
Western juniper: JUOC and mix-JUOC;
Ponderosa pine: PIPO and mix-PIPO;
Douglas-fir: PSME and mix-PSME;
Western larch: LAOC and mix-LAOC;
Broadleaved trees: POTR, POTR2, mix-POTR, and mix-POTR2;
Lodgepole pine: PICO and mix-PICO;
Western white pine: PIMO and mix-PIMO;
Grand fir: ABGR and mix-ABGR;
Whitebark pine: PIAL and mix-PIAL;
Subalpine fir and spruce: ABLA, PIEN, mix- ABLA, and mix-PIEN.

Table 10: RV information for forest structural stage for dry upland forest PVG.

Forest Structural Stage	Range of Variation (Percent)
Stand initiation	15-30
Stem exclusion	10-20
Understory reinitiation	0-5
Old forest single stratum	40-65
Old forest multi strata	1-15

Sources/Notes: Derived from disturbance process modeling based on Vegetation Dynamics Development Tool (VDDT) (Powell 2019c). Forest structural stages are illustrated and described in table 8.

Table 11: RV information for tree density for dry upland forest PVG.

Tree Density Class (mixed species composition at a quadratic mean diameter of 10")	**Range of Variation (Percent)**
Low (<47% canopy cover; <55 ft^2/ac basal area; <103 tpa or sdi)	40-85
Moderate (47-55% canopy cover; 55-85 ft^2/ac basal area; 103-154 tpa or sdi)	15-30
High (>55% canopy cover; >85 ft^2/ac basal area; >154 tpa or sdi)	5-15

Sources/Notes: Tree density class values derived from table 7 and Powell (2013b); range of variation values derived from Schmitt and Powell (2012). Note that tpa refers to trees per acre; sdi refers to stand density index. All 'tree density class' values pertain to mixed-species, even-aged stands (a species mix of 70% ponderosa pine, 20% Douglas-fir, and 10% grand fir). Tpa and sdi values are the same because sdi uses a 10" quadratic mean diameter (QMD) as a reference tree size; if QMD had been any value other than 10", tpa and sdi values would not have been identical.

Table 12: RV information for insect and disease susceptibility for dry upland forest PVG.

Insect and Disease Agents[1]	**Range of Variation (Percent)**
Defoliating insects	
Low susceptibility	40-85
Moderate susceptibility	15-30
High susceptibility	5-15
Douglas-fir beetle	
Low susceptibility	35-75
Moderate susceptibility	15-30
High susceptibility	10-25
Fir engraver	
Low susceptibility	45-95
Moderate susceptibility	10-25
High susceptibility	5-10
Bark beetles in ponderosa pine	
Low susceptibility	35-75
Moderate susceptibility	15-35
High susceptibility	10-20
Mountain pine beetle in lodgepole pine	
Low susceptibility	55-90
Moderate susceptibility	5-35
High susceptibility	0-5
Douglas-fir dwarf mistletoe	
Low susceptibility	30-60
Moderate susceptibility	10-35
High susceptibility	20-35
Western larch dwarf mistletoe	
Low susceptibility	55-95
Moderate susceptibility	5-30
High susceptibility	0-5

Insect and Disease Agents[1]	Range of Variation (Percent)
Root diseases	
Low susceptibility	35-75
Moderate susceptibility	20-35
High susceptibility	5-20

Sources/Notes: Derived from Schmitt and Powell (2012). Queries for calculating susceptibility ratings for forest polygons are available from Schmitt and Powell (2005).

[1] Defoliating insects includes western spruce budworm and Douglas-fir tussock moth; bark beetles in ponderosa pine includes western and mountain pine beetles; root diseases include laminated root rot and Armillaria root disease.

7.10 Climate Change Considerations

A pressing environmental matter of critical concern is a long-term and ongoing increase in surface temperature of the earth. This threat goes under several names – climate change and global warming are probably most common. Global warming exacerbates a natural process called the ‘greenhouse effect,’ referring to a principle of a greenhouse in that an enclosing shell allows passage of incoming sunlight but traps a portion of reflected infrared radiation, warming a greenhouse’s interior above outside temperatures.

Greenhouse gases in earth’s atmosphere play a similar role to a greenhouse’s shell – they function to raise temperature of the earth and make it habitable. Without greenhouse gases, surface of the earth would be about 30 °C (54 °F) cooler than it is today, rendering human life impossible.

Since beginning of what is termed an ‘industrial era’ (mid 1700s), combustion of fossil fuels, together with permanent deforestation and a few other anthropogenic activities, has caused an increase in carbon dioxide content of the atmosphere of more than 40 percent. In the last three decades alone, it has increased by almost 20 percent. An approximate doubling of carbon dioxide levels could occur by middle of 21st century, depending on rates of fossil fuel burning over next few decades.
[After excluding water vapor, the most abundant greenhouse gas, carbon dioxide is currently about 77% of all remaining greenhouse gases, with others being methane (14%), nitrous oxide (8%), and several trace gases (carbon monoxide, ozone-depleting chemicals, halocarbons, etc.).]

Instrumented temperature records, along with gas composition of ice associated with long-lived glaciers and ice fields, show that the earth has warmed about 0.7 °C (1.3 °F) over the past 100 years. Some climate models predict that during this century, temperatures could rise by 1.5 to 4.5 °C, or about 0.3 °C per decade. This might not sound like particularly rapid change, but historical studies have shown that past episodes of warming and cooling occurred at a rate of only about 0.05 °C per decade, and this amount of historical change was sufficient to cause major dislocations for human agrarian societies (Mann 2006).

Climate change effects are not uniform – in the northern hemisphere, polar regions are warming faster than equatorial zones, and centers of continental landmasses are becoming drier than their peripheries. In ice ages of the past, weather changed gradually enough to allow plants and animals to migrate and survive; rapid pace of change occurring now is likely too quick to allow many organisms to adjust to modified habitats. For this reason, some of the most concerning human impacts of climate change could involve agriculture and forestry and, of the two, forestry has fewer mitigation or adaptation options than agriculture (narrative to this point in section 7.10 is based primarily on Karl et al. 2009).

Much concern about climate change relates to how it will affect baseline climate conditions. But will climate change effects be additive, subtractive, or neutral on baseline temperature and moisture relationships, and will their magnitude be great enough to exceed environmental tolerances of existing plant species (table 13)? If an answer to the second question is yes, then one likely effect of climate change will be extirpation of certain plant species, and their related fauna and ecosystem services, from portions of the Blue Mountains (Kerns et al. 2017, 2018).

When considering precipitation patterns, it's not just potential for more and longer future droughts that is problematic (Adams et al. 2009, Hanson and Weltzin 2000, Voelker et al. 2019, Vose et al. 2016) – it's the projected change in precipitation form, with less being received as snow and more as rain (fig. 39). This trend might actually improve forest growth by lengthening the growing season into early spring, when soil moisture is at a maximum.

Because the Blue Mountains have a summer-dry, Mediterranean climate where soil-based snowmelt storage is crucial for sustaining tree growth across a relatively long growing season, a change in precipitation from snow to rain is much more likely to induce earlier summer plant dormancy, lengthen the fire season, shorten the wetland saturation period, and affect many other ecosystem goods and services (van Mantgem et al. 2009). In addition to lengthening the fire season (Hamilton et al. 2016), higher temperatures contribute to extensive fuel drying, making dry forests more flammable (Abatzoglou and Williams 2016).

Certain life history traits in table 13, such as 'tolerance to frost,' might seem unrelated to climate change. But climate change has apparently influenced the cold hardiness of trees, with boreal forests experiencing earlier loss of cold hardiness in response to early-spring warming (late April to early May), followed by severe frost damage during subsequent cold snaps in mid spring (mid to late May) (Man et al. 2009). Before onset of climate change, frost damage in mid-May was unusual because boreal trees had not lost cold hardiness at that point in a year.

Ecological changes described earlier in this white paper, as related to fire exclusion, ungulate herbivory, and selective cutting (Harrod et al. 1999, Mast et al. 1999, Sloan 1998b, Turner and Krannitz 2001), have put dry-forest ecosystems on precisely a wrong trajectory when considering the warm, fire-favoring climate expected for the 21st century (fig. 40) (Brown et al. 2004, Flannigan et al. 2005, Gillett et al. 2004, Macias Fauria and Johnson 2006, Miller et al. 2009, Running 2006, Spracklen et al. 2007, van Mantgem et al. 2009, Westerling et al. 2006).

An important bottom-line is: "Designing more fire-resistant stands and landscapes will likely create forests that are more resistant and resilient to the changes imposed on them by climate change" (Stephens et al. 2012b).

Table 13: Selected life history traits for five primary conifers of dry forests.

	Western juniper	Ponderosa pine	Western larch	Douglas-fir	Grand fir
Tolerance to shading	L	L	L	M	H
Tolerance to full sunlight	H	H	H	M	L
Seral status	Early	Early	Early	Mid	Late
Tolerance to frost	L	L	L	L	M
Tolerance to drought	H	H	M	M	M
Rooting habit (depth)	S/M	D	D	D	S
Fire resistance	L/M	H	H	M/H	L/M
Evolutionary mode	NR	Inter	Inter	Spec	NR
Seed germination on charred or ashy soil	NR	IN	NE	IN	IN
Maximum seed dispersal distance (feet)	NR	120	150	330	200
Potential for regeneration in the open	H	H	H	H	L
Overall reproductive capacity	M	H	H	H	M
Potential initial growth rate (first 5 years)	L	H	H	M	M

Sources/Notes: Ratings derived from a variety of literature sources. Rating codes are: L, low; M, moderate; H, High; D, deep; S, shallow; IN, increased; and NE, no effect. Overall reproductive capacity considers minimum cone-bearing age, seed crop frequency and size, seed soundness, and related factors. Evolutionary mode refers to an amount of genetic differentiation; it indicates how well a species could adapt to future climates (Inter is intermediate; Spec is specialist; NR is not rated; source = Rehfeldt 1994).

"A century of fire suppression and timber extraction has led to denser forests, with higher numbers of smaller diameter trees and larger fuel loads supporting larger, more intense fires (Hurteau and North 2010). However there is disagreement about whether these forests store more carbon now in comparison to the past – some researchers argue that because these forests have fewer mature, large trees they have lower carbon storage compared with historical levels (North and others 2009). Others suggest that current levels of carbon storage are higher than historical levels because of fire suppression (Harmon and Marks 2002; Reinhardt and Holsinger 2010)" (Ellenwood et al. 2012, p. 962).

These carbon accounting concerns are important because Collins and others (2011) found that a better approximation of historical structure and composition was produced when old forests were burned, as a restoration treatment, at moderate rather than low severity (with moderate severity ostensibly reducing carbon storage to a greater extent than low severity). This result occurred because higher fire intensity was needed to kill a sufficient number of intermediate-sized trees resulting from decades of fire exclusion. ["we now have millions of acres where fire-resistant ponderosa pines are surrounded by shorter trees that grew to 40, 50, or even 75 feet tall, but only because they escaped fire when just three or four feet high" (page 47).]

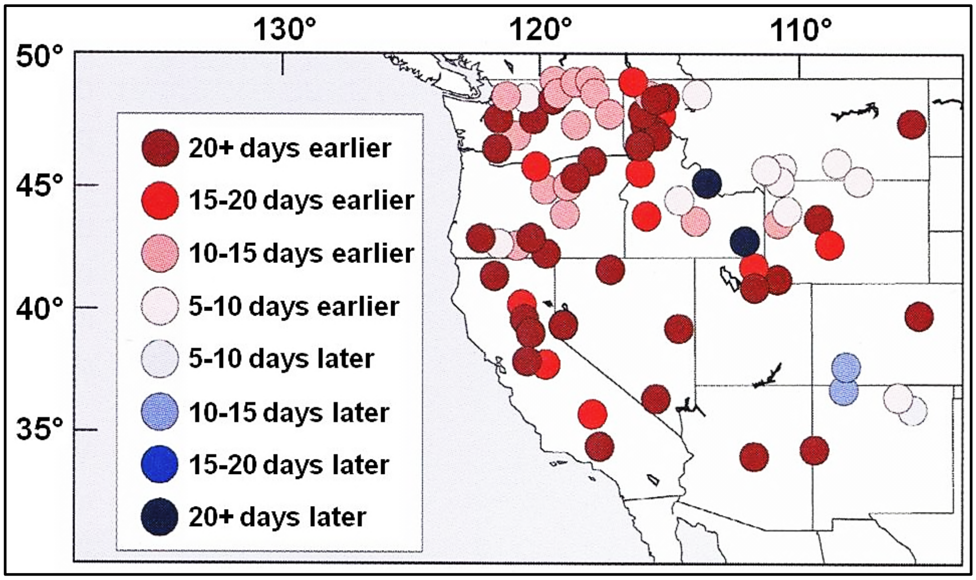


Figure 39 – Recent changes in spring snowmelt timing for western United States (from Karl et al. 2009, p. 33). This chart shows trends in streamflow runoff timing for 1948-2000, as a number of days runoff occurs earlier. According to this analysis, northern Blue Mountains river basins occur in a zone where runoff occurred 10-20+ days earlier for a 1948-2000 period than it did previously. Future climate change is expected to continue and exacerbate this trend (Furniss et al. 2010, Stewart et al. 2004).

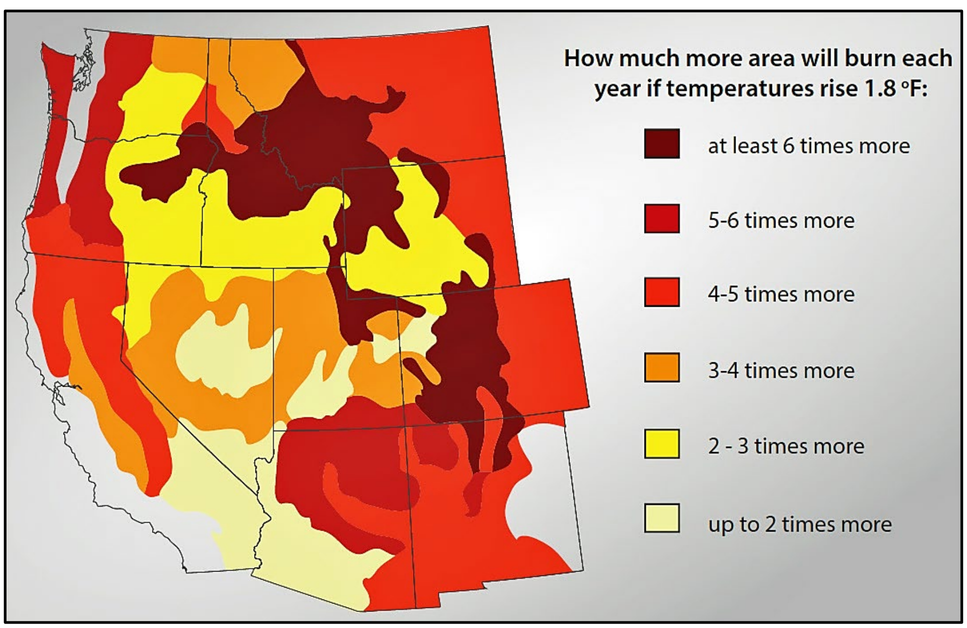


Figure 40 – Predicted increase in area burned by wildfire as associated with a mean annual temperature increase of 1 °C (1.8 °F), shown as percentage change relative to median annual area burned during 1950-2003 (source: Climate Central 2012). Results are aggregated to ecoprovinces (Bailey 1995) of western US. Climate-fire models were derived from National Climatic Data Center records and observed burned-area data following methods described in Littell et al. (2009). Prediction shown here is similar to several reports from National Research Council showing at least a quadrupling of area burned in western US with each 1 °C (1.8 °F) of temperature increase (this figure adapted from figure 5.8 in National Research Council 2011).

Predicted increases displayed in figure 40 are alarming because when examining a century-long period from 1970-99 to 2070-99, increases in average annual temperature of 3.3 to 9.7 °F are projected, depending largely on whether global emissions eventually decline (B1 greenhouse gas emissions scenario) or continue to rise (A1B, A2 emission scenarios), and temperature increases are projected to be largest in summer when they would coincide with fire season.

If dry mixed-conifer forests are to have a reasonable opportunity for persistence under future climate regimes, restoring conditions more similar to historical characteristics of frequently burned, open forests of the past is likely to function as a useful start point (Fiedler 2000b, Harrod et al. 1999, Munger 1917, Stockdale et al. 2019).

Although debate continues about how, where, and to what extent reference conditions derived from historical ecology should be used for land management (Millar and Woolfenden 1999), consensus is growing that it is useful to know and understand the past to properly manage future ecosystems (Swetnam et al. 1999).

Sustainable, dry-forest conditions can be achieved by reintroducing surface fire, and by implementing thinning treatments, to change fire-free intervals from centuries to decades, to reduce surface fuels, and to reduce canopy and ladder fuels to counteract a compositional trend toward increased representation of fire-sensitive trees (fig. 41).

These restoration treatments could help reestablish spatial heterogeneity (fig. 42). "A lack of treatment or passive management (Stephens and Ruth 2005) perpetuates the potential for extensive high fire severity in forests that once burned frequently with low- to moderate-intensity fire regimes" (Stephens et al. 2012b).

"Thinning is thought to reduce the risk of stand-replacing fires and the corresponding sudden release of large amounts of carbon to the atmosphere (Hurteau and others 2008; Dore and others 2010; Reinhardt and Holsinger 2010). However, the effects of thinning and fuels treatment on overall carbon balance are complex. The ultimate effect of thinning and fuels treatment on carbon stocks is affected by the initial state of the forest, the types of treatments conducted (e.g., mechanical thinning versus prescribed burning), and the time period over which one compares the carbon balance (North and others 2009; Hurteau and North 2010). Some researchers suggest that while thinning and other mechanisms to reduce fire risk reduce the overall carbon stocks in the forest by a moderate amount in the short run, if the treated forest subsequently supports the growth of larger mature trees it may end up storing as much carbon as it did before treatment, in a landscape that is less susceptible to large stand-replacing fires (North and others 2009; Reinhardt and Holsinger 2010)."

"Because the carbon balance continues to change as the forest recovers long after the fire event, there is much uncertainty about how long it might take for the carbon balance to be back in equilibrium (Dore and others 2010; North and others 2009; Kashian and others 2006). In addition, the fate of thinned material influences the overall carbon impact, e.g., by sequestering carbon if the material goes into long-lived products such as timber or displacing fossil fuel emissions if used to produce biomass energy (Harmon and Marks 2002)" (quoted material in two paragraphs above from Ellenwood et al. 2012, p. 962).

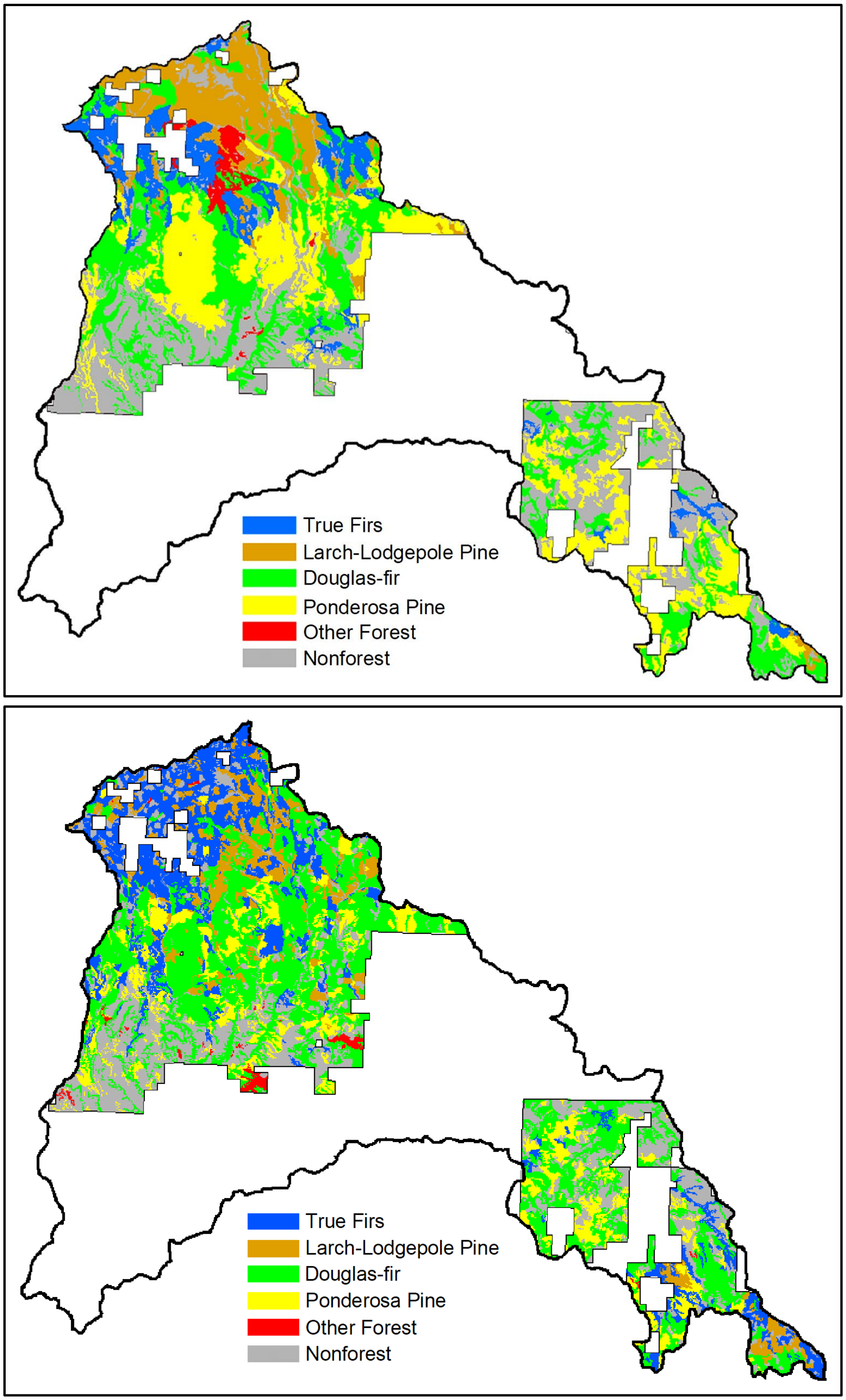


Figure 41 – Historical (upper; 1939 conditions) and existing (lower) vegetation cover types for Potamus watershed, Umatilla NF. When comparing these two maps, ponderosa pine type declined, and Douglas-fir and true-firs types increased.

Figure 42 – Reintroduction of spatial heterogeneity into Wild Horse prescribed fire area. Blue Mountains experience over past 20 years suggests that adopting a conservative approach to restoration of dry forests is not a choice of 'no action' because a passive strategy accepts risk of high-severity wildfire and other uncharacteristic disturbance (see fig. 19). Upon recognizing that risks of no action are probably unacceptable for many scenarios, land managers must design flexible, adaptive treatments to restore high levels of spatial heterogeneity for dry forests (Agee and Skinner 2005; Allen et al. 2002; Hessburg et al. 2000, 2007; Wright and Agee 2004) (and, see figs. 44-45 later in this paper).

Restoration prescriptions that lack prescribed fire are incomplete because thinning alone is not sufficient to renew nutrient cycling processes for dry sites. And, if scale of management activity does not emulate scale of native disturbance processes, then we can expect ecosystem responses such as reduced biological diversity and impaired nutrient cycling (Baydack et al. 1999, Eng 1998). And, scale includes temporal considerations as well – seasonality of historical fires, for example, follows a latitudinal gradient for the Blue Mountains, with predominantly early-season fires in southern Blues and late-season fires in northern Blues (Heyerdahl et al. 2001).

Forest trees in an upper canopy layer have better access to sunlight, nutrients, and moisture than trees in subordinate positions. Since dominant trees use a disproportionate share of site resources, it seems logical they are little influenced by subordinate trees (Daniel et al. 1979, Smith et al. 1997). Research in central Oregon (Barrett 1963, 1972) and elsewhere in the West (Dolph et al. 1995, Stone et al. 1999), however, showed that competition is a reciprocal process; removing subordinate trees, by using a low thinning to remove many intermediate and subcanopy/suppressed trees, results in dramatic vigor increases for dominant ponderosa pines (Woodall et al. 2003), particularly for old-growth stands and during drought periods.

Note that dry-forest restoration activities are envisioned for implementation on Blue Mountain areas **currently** classified as dry upland forest; no attempt has yet been made to predict how this biophysical environment might expand, contract, or migrate in response to future climate change. Although any attempt to model how Dry Upland Forest (UF) PVG might increase at expense of Moist UF or Cold UF PVGs is speculative at this point, several climate change scenarios examined for the interior Pacific Northwest suggest that this is a likely outcome (Dello and Mote 2010, Kerns et al. 2017, 2018).

There is also no assurance that current amounts and spatial configuration of dry forest will remain the same under climate change. Research suggests that changes in fire regimes due to climate feedbacks led to expansion of savanna environments (open tree stands whose physiognomy is more reminiscent of grassland than forest) in response to hotter and drier conditions (Bond et al. 2005, Bowman et al. 2009). Based on circumstances under which it has occurred elsewhere, a savanna outcome is certainly plausible for some proportion of dry-forest acreage located within a Blue Mountains ecoregion (Kerns et al. 2018).

Many policy proposals being considered to address climate change are based on mitigation – reducing greenhouse gas emissions from fossil fuels and land-use changes to minimize pace and magnitude of climate change. While mitigation is important, adaptation to climate change is increasingly viewed as a necessary and complementary strategy to mitigation (Joyce et al. 2009). Table 14 provides adaptation strategies proposed for National Forest System lands, and pertaining to upland forest vegetation. Table 14 also describes predicted compatibility of active management treatments with climate change adaptation strategies.
Note: some sources frame a mitigation/adaptation couplet as resistance/resilience – near-term resistance measures, such as thinning, need to be fully coordinated with far-term resilience strategies (e.g., creating climate-adapted genotypes by establishing new tree regeneration).

Information in table 14 suggests that active management practices reducing stand vulnerability to uncharacteristically severe wildfire and other climate-influenced disturbance processes could satisfy multiple goals of near-term mitigation (by minimizing fire-related carbon emissions) and mid-term adaptation if such practices also reflect goals for other ecosystem services such as late-old structure and water quality (Joyce et al. 2009).

Potential for uncharacteristically severe wildfire is particularly high – of 47 million acres of federal land in the Pacific Northwest, approximately 47 percent (22.6 million acres) was historically affected by short interval fire (these are dry sites once dominated by ponderosa pine, shrubs, or bunchgrasses). A majority of these lands are located east of Cascade Mountains in Washington and Oregon. Of the acres with a short-interval fire regime, 71 percent (16 million acres) currently have a higher predicted fire severity (risk) than existed historically (fig. 43).

Future activities could be designed to favor species whose life-history traits are most compatible with future climatic conditions. These traits are presented in table 13 for five primary tree species of dry upland forest sites. But even so, we also need to realize that as stock brokers like to say: "past performance is no guarantee of future success."

Proposed restoration activities would improve adaptive capacity (Olsson et al. 2004) of dry mixed-conifer forests in the Blue Mountains, particularly by alleviating chronic stress associated with high tree density levels, and by reestablishing an historically appropriate structural condition (fig. 44). A recently developed option for reestablishing a groupy or clumpy condition in dry forest is to apply an ICO approach (Churchill et al. 2013a, 2013b; Franklin et al. 2013) (fig. 45).

Table 14: Estimated compatibility of climate change adaptation strategies and active management of dry upland forests.

Climate Change Adaptation Strategies	Compatibility With Dry-Forest Management
Improve ecosystem capability to withstand uncharacteristically severe drought, wildfire, and insect infestation at landscape scales.	Thinning and similar active management practices might be necessary to improve resistance and resilience of dry-forest vegetation, upon which many ecosystem services depend.
Facilitate natural (evolutionary) adaptation through silvicultural treatments that shorten regeneration times and promote interspecific competition.	Adaptation strategies often recommend regeneration cutting because existing stands are adapted to century-old climates, so new seedlings would then become adapted to future (changed) climates.
Where ecosystems will very likely become more water limited, manage for drought- and heat-tolerant species.	When circumstances permit, composition could be changed to favor species with high tolerance to drought, open conditions, and fire (table 13).
Reduce homogeneity of stand structure and synchrony of disturbance patterns across broad landscapes by promoting diverse age classes and species mixes, stand diversities, and genetic diversity.	This strategy could best be addressed by perpetuating age-class diversity, introducing additional species diversity when appropriate, and trying new genotypes offering better environmental fitness.
Reset ecological trajectories to take advantage of early successional stages compatible with present, rather than past, climates.	Composition could be changed to favor early-seral species with high tolerance or resistance to drought, open conditions, and fire (table 13).
Use historical ecological information to identify environments buffered against climate change, and that would be good candidates for conservation.	Many literature sources provide historical information with relevance for dry-forest ecosystems (Gannett 1902, Munger 1917, and others).
Encourage local industries that can adapt to or cope with variable types of forest products because of uncertainty about which tree species will prosper in the future.	Small-diameter trees will be removed frequently as restoration activities are implemented and, depending on the circumstances, they could be used for biomass purposes.
Reforestation after disturbance may require different species than were present before disturbance to better match site-level changes associated with climate change.	We can use life-history data such as fire resistance and drought tolerance (table 13) to reforest with species having high resilience to future climates. But should we also consider new species?
After a disturbance event, use intensive site preparation activities to remove competing vegetation and replant with high-quality, genetically appropriate, and diverse plant materials.	This recommendation is similar to one just before it, but with additional detail. It is feasible to use site preparation before planting, but any 'intensive' measures need to protect soil integrity.
To promote climate resilience for existing stands, use widely spaced thinnings or shelterwood cuttings and rapid response to forest mortality from fire or insects.	Wide thinning spacings and shelterwood seed cuttings are compatible with dry upland forests. Rapid response to mortality helps address increased fire and insect risk related to climate change.
Plan for higher-elevation insect outbreaks, species mortality events, and altered fire regimes.	It is expected that some fire regime 3 (mixed-severity) areas could transition to fire regime 1 (low severity) as future climate warms and dries.

Sources/Notes: Adaptation strategies pertain to forest environments only, and are derived from Joyce et al. (2008, 2009) and West et al. (2009). Only forest-centric compatibilities are addressed in this table.

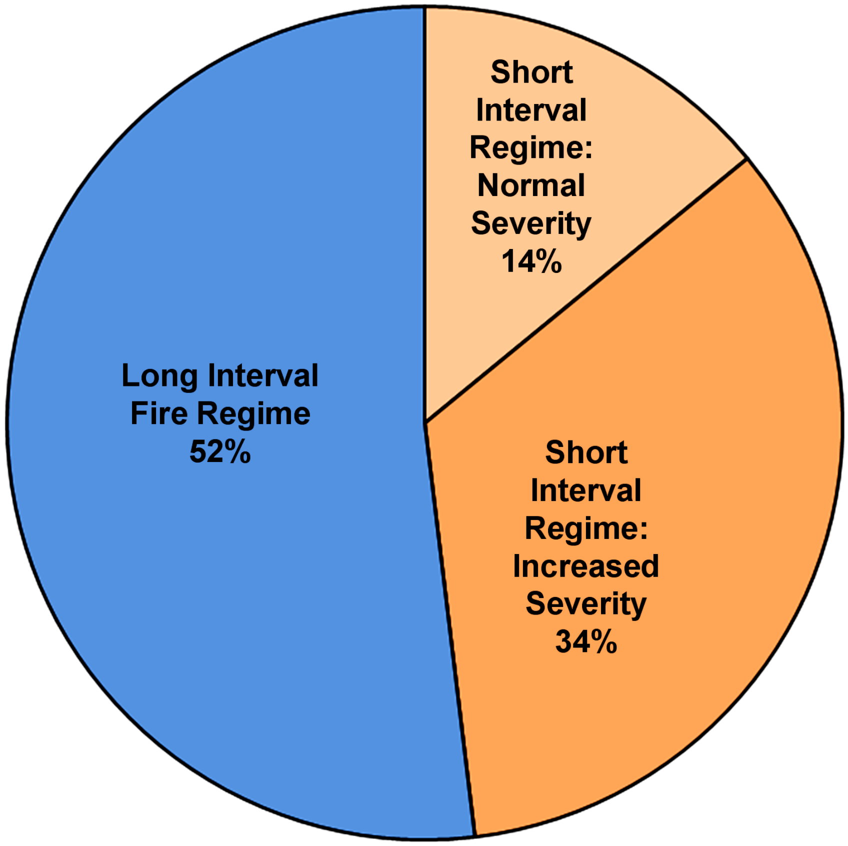


Figure 43 – Trend toward increasing fire susceptibility for short-interval fire regimes of Pacific Northwest.[1] Many sources show the scale of predicted change in fire severity for fire regime 1 sites to be enormous (Hessburg et al. 2005, Hann et al. 1997, Quigley et al. 1996). When considering 47 million acres of federal lands in Pacific Northwest administered by Bureau of Indian Affairs, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and U.S. Forest Service, about 48% can be assigned to a short-interval fire regime (fire regimes 1 and 2). Of this dry-site acreage, 71% (16 million acres, or 34% of total acreage) currently has a higher predicted fire severity (stand-replacing) than would have existed historically (stand-maintaining). When General Accounting Office evaluated catastrophic fire risk for western U.S., its report concluded that "the most extensive and serious problem related to the health of national forests in the interior West is the over-accumulation of vegetation." GAO estimated that about 39 million acres of national forests in the West have high fire risk due to excessive fuel buildup; they estimated that $12 billion would be needed between 1995 and 2015 to reduce excess fuel accumulations, an average expenditure of $725 million annually (GAO 1999).

Many dry-forest studies suggest that a large proportion of remaining 200+ year-old ponderosa pines shown in figures 44-45 are likely to die in next few decades, particularly as a result of western pine beetle attack (fig. 36), unless major restoration treatments are completed (Lynch et al. 2000). Many of these veteran trees could survive for another century or more if dry-forest composition, structure, and density is returned to historical conditions (fig. 46).

[1] This figure includes federal lands administered by Bureau of Indian Affairs, Bureau of Land Management, National Park Service, US Fish and Wildlife Service, and US Forest Service (data derived from a draft report released by Pacific Northwest Wildfire Coordinating Group in June 2000; 28 p.).

Figure 44 – Many dry forests still have remnant historical structure such as this clump of mature ponderosa pine. Historically, dry forests tended to be uneven-aged at a stand level, with stands consisting of small even-aged tree clumps, each differing in age from others (Cooper 1960, 1961a; Munger 1917; White 1985). Historical clump size for dry forests ranged from 0.01-0.05 acres for central Washington (Harrod et al. 1999) to 0.37-0.44 acres for central Oregon and northeastern California (Youngblood et al. 2004). So for dry forests, patch size (e.g., an opening large enough to sustain regeneration) is quite small – 0.6 acres or less (Agee 1998). Restoration treatments can be used to remove late-seral species (Douglas-fir and grand fir) from this clump, improving its resistance and resilience to climate change.

Figure 45 – Tree clumps in ponderosa pine forest. When evaluating spatial heterogeneity for dry forests, it is important to consider a sub-stand level because scale is fine-grained and intricate for dry forests – ponderosa pine stands historically featured a groupy or clumpy structure at a sub-stand scale (Harrod et al. 1999). What are sources of these clumps? As described in section 4, variable thinning effects caused by frequent surface fire was certainly an important factor. Another factor relates to seed caching by deer mice, golden-mantled ground squirrels, chipmunks, shrews, and other small mammals (Keyes et al. 2007; Saigo 1969; Vander Wall 2002, 2003) because unutilized seed caches also result in tree clusters. Pine clumps can contain few (above) or many trees (below); an intertree distance of 6 meters (app. 20 feet) is sometimes used to identify clump 'membership' (trees < 6m apart are in a clump, whereas trees > 6m apart are out). A recent approach for reestablishing spatial heterogeneity in dry forests is an ICO (Individuals, Clumps, Openings) methodology (Churchill et al. 2013a, 2013b; Franklin et al. 2013).

Figure 46 – Clumps of old ponderosa pines surrounded by ponderosa pine regeneration, southern Blue Mountains (Malheur National Forest). Other images in this white paper show old pines surrounded by regeneration of mid- or late-successional trees such as Douglas-fir or grand fir (see figs. 27 and 44). However, dense regeneration of ponderosa pine intermixed with, or adjacent to, old ponderosa pines is problematic, even though the regenerating species is ecologically appropriate for dry sites. Completing an 'understory removal' treatment to remove pine regeneration, within at least 2 driplines of mature trees, is beneficial for reestablishing an historically appropriate stand structure, and it responds to our long-term suppression of nature's thinning agent – frequent, recurring surface fire.

A common goal of dry-forest restoration is to develop more open structures consistent with historical disturbance regimes (Arno et al. 1995), an outcome also considered to be compatible with a warmer and dryer future (Brown 2008, Stephens et al. 2013). This goal agrees with studies reconstructing composition and structure for dry sites because they report much lower stem densities than today, larger trees, and a strong clumping pattern for overstory trees (see table 2; Churchill et al. 2017; Harrod et al. 1999; Johnston et al. 2016, 2017, 2018).

Climatic drought is projected to be more common in the future (Hanson and Weltzin 2000) because mid-summer temperatures are expected to be higher, and summer precipitation lower, than at present. But, dense stands exist in a sort of perpetual 'physiological' drought because intertree competition results in a situation where not enough soil moisture is available to meet water needs of all trees (regardless of rainfall amounts); silvicultural treatments are used to alleviate this moisture stress and allow residual trees to survive and continue growing.

Since climate change will amplify effects of density-caused stress, the need for future thinning is expected to be much greater than at present, particularly because thinning improves physiological vigor, and trees with improved vigor produce more resins used to repel insect and disease attacks (Kolb et al. 1998, Langenheim 1990, Mitchell et al. 1983, Nebeker et al. 1995, Phillips and Croteau 1999, Pitman et al. 1982, Safranyik et al. 1998).

Direct effects of climate change on temperature and precipitation, in conjunction with indirect effects from wildfires, insect outbreaks, and other disturbances that will continue ramping up as climate changes, could detrimentally affect future provision of ecosystem goods and services (Krieger 2001), including old forest, properly functioning soil and water services, wildlife habitat, animal and plant diversity, recreational opportunities, and carbon storage (fig. 47).

Climate modeling suggests that western larch could be extirpated from Blue Mountains by early 22nd century (Rehfeldt et al. 2006). And although studies were not specific to the Blue Mountains, recent developments across western U.S. suggest that quaking aspen is also quite sensitive to climate change (Rehfeldt et al. 2009, Rogers et al. 2007, Worrall et al. 2010).

Although aspen is generally perceived as being associated with moist or mesic conditions (fig. 47), aspen is also a dry-site species – a Dry Upland Forest potential vegetation group includes 8 potential vegetation types dominated by aspen (see appendix 1).

Effective resistance treatments must consider the landscape context in which they occur – Finney and others (2007) compared effectiveness of different rates of fuels treatment over several decades for western U.S., and they found that treatment rates beyond 2% of a landscape per year, based on optimized treatment placement (such as 'strategic placement of landscape area treatments' or SPLATs), yielded little additional benefit (Stephens et al. 2012b).

Treatment timing is also important. Although cut-burn treatment combinations are consistently effective at restoring dry forests, it has also been found that burning too soon after thinning can result in delayed tree mortality (Fajardo et al. 2007). [A consistent management implication from many dry-forest restoration studies is that direct reduction of overstory density (thinning), in combination with renewal of nutrient cycling mechanisms (burning), yields the highest increases in undergrowth plant and overstory tree vigor.]

Figure 47 – Fenced clone of quaking aspen located along 5316 road on North Fork John Day Ranger District (aspen is short and has yellow foliage). Aspen reproduces almost exclusively from root suckers, resulting in a clonal life history where its root system functions as a genet, producing successive generations of suckers called ramets. Ramets develop into mature trees. Although aspen ramets are relatively short-lived (60 to 100 years is common), an underground genet may be thousands of years old. Some clones in the intermountain West approach 10,000 years of age (and perhaps more than a million years according to Barnes 1975), thus producing a hundred or more generations of ramets from a single root system. Genetic testing indicates that an ancient aspen clone has existed for thousands of years in Morsay Creek drainage, approximately 15 miles west of Ukiah, Oregon (Shirley and Erickson 2001).

Aspen is a very intolerant tree species (Daniel et al. 1979, p. 297), which means it only regenerates and develops acceptably in open environments. When competing with more tolerant species, particularly conifers, aspen quickly loses vigor as shading, soil acidity, and other conditions evolve to favor competitors. A common restoration tactic for maintaining and sustaining aspen in the Blue Mountains is to remove conifers, but this practice is controversial when competing conifers are old ponderosa pines (but, 200-year-old pines are obviously younger than a 1000-year-old aspen root system).

This photograph also shows buck-and-pole, A-frame style fencing installed around an aspen clone as a way to address ungulate herbivory caused primarily by cattle and elk (fencing includes both current extent of aspen stems and some expansion space). Fencing is used to exclude ungulates for a period long enough to allow aspen suckers to reach a sufficient size (in both height and stem caliper) where they can withstand some browsing pressure and still develop into a viable overstory cohort.

Aspen has a surprising affinity for dry-forest environments (e.g., it occupies moist microsites within a broader warm dry biophysical setting), as illustrated by a recent classification of quaking aspen types – of 15 aspen plant community types identified for the Blue Mountains, 8 of them occur in a Dry Upland Forest potential vegetation group (see appendix 1; Swanson et al. 2010).

It has been suggested that increasing the time interval between thinning and burning treatments could reduce amounts of delayed mortality by allowing more time for residual trees to increase their post-thinning vigor, and by allowing thinning-created surface fuel to decompose before completing a prescribed fire (fig. 48).

Another potential benefit of increasing time interval between thinning and burning is that it lengthens the total period for which treated areas have reduced fire hazard (i.e., burning quickly after thinning will result in an area returning to pretreatment fuel hazard levels more quickly than by waiting a little longer between treatments) (Stephens et al. 2012b). And, as climate continues to warm and dry, treating dry-forest areas to reduce fire hazard allows them to be maintained in a low-hazard state by using a 'managed wildfire' approach (North et al. 2012), which is an increasingly attractive option as wildfire acreage (fig. 40) and fire suppression costs continue to increase (Haughian et al. 2012, Littell et al. 2009).

Obviously, changes of the magnitude described in this section would cause 'ripple effects' across many biological webs and trophic levels (Perry et al. 2008). If climate change precludes us from sustaining desired levels of ecosystem composition, structure, and density, then how can we sustain the ecosystem goods and services contingent on these components? I believe the best answer to this question, as hopefully demonstrated by this white paper, is to apply correct dry-forest restoration practices, in correct places, at proper times, and for correct reasons.

SUMMARY: ESSENTIAL TENETS OF DRY-FOREST MANAGEMENT

This white paper discusses how three primary human influences affected dry forests – fire exclusion, livestock grazing, and selective cutting. Other factors also contributed to changes:

- Dry forests often have low ecological integrity, particularly in response to suppression of surface fire, a keystone ecosystem process for this biophysical environment.
- For a majority of dry-forest sites, low-severity surface fire has now been replaced, in many areas, by high-severity crown fire (Stephens et al. 2020).
- Forests comprised primarily of late-seral structural stages have declined, especially for an old forest single stratum stage dominated by large-diameter ponderosa pines.
- Mid-seral structures have increased, contributing to landscapes that are much more homogeneous than they were historically (Quigley et al. 1996).
- Contemporary dry forest has markedly higher tree density and understory fuel loading, while simultaneously exhibiting much lower undergrowth productivity and diversity.

- Existing stand density is often inconsistent with an historical disturbance regime – uncharacteristically high density levels are common across dry landscapes of the federal estate.
- Forest canopies are more complex and layered due to loss of thinning agents; the resulting multi-layered structure is now ladder fuel and provides a budworm feeding ladder.
- Wildfires and defoliating insects (mainly western spruce budworm and Douglas-fir tussock moth) now occur with uncharacteristic, stand-replacing severity on many dry landscapes.
- Largely in response to fire exclusion and livestock grazing, dry forest expanded onto sites historically supporting woodland, shrubland, or grassland vegetation (Munger 1917).
- High livestock grazing levels in early 1900s affected tree regeneration by reducing herbaceous competition with seedlings, and by exposing mineral soil for tree-seed germination.
- Historical disturbance regimes provide a blueprint for active management to maintain ecological function; treatments must emulate native disturbance and succession processes.
- Stand density changes led to declines in individual-tree vigor, increased probability of bark beetle attack (Christiansen et al. 1987), and contributed to higher probability of uncharacteristic wildfire. Stand density changes also influence rates of surface fuel accumulation.
- Thinning and prescribed fire, applied in proper places and at appropriate times, is needed to help recover ecological integrity and resilience of dry-forests (Hessburg et al. 2015).
- Thinning and prescribed fire are effective for sustaining high vigor levels for old ponderosa pines; high vigor translates into increased resin production and chemical defenses against western pine beetle and other insects and diseases (Kolb et al 1998b).
- Thinning to low stocking levels is especially important in a climate-changed future (Kerns et al. 2017, 2018) because wildfire may convert dry forests to shrublands or herblands, whereas trees in thinned areas will survive and promote a fire-compatible savanna structure.
- In early 1990s, fire scientists recommended that prescribed fire use be increased tenfold for Blue Mountains national forests to address forest health (Mutch et al. 1993); unfortunately, and for many and varied reasons, large increases in prescribed-fire use did not occur.
- To support increased utilization of prescribed fire, dry forest should be managed to sustain coarse woody debris (CWD) levels ranging between 5 and 20 tons per acre (defined as dead standing and downed pieces larger than 3 inches in diameter). Between 4 and 7 tons per acre of a 5-20 ton per acre CWD range would exist as standing snags at a total rate of 6 to 14 stems per acre (2 to 4 snags per acre should be at least 15" in diameter) (see section 7.4).
- Less low-severity disturbance results in species composition (including nonforest) being less diverse now than historically; more tree species are now present on dry sites after ponderosa pine was joined by Douglas-fir, grand fir, and western juniper (Gedney et al. 1999).
- Historical timber harvest removed large, fire-resistant ponderosa pines. Future harvest could use uneven-aged management to restore intra-stand heterogeneity (fig. 49).
- Small trees got established abundantly (appendix 3), and many of them are fire-sensitive species (Douglas-fir, grand fir). Small trees act as ladder fuel during wildfires, causing individual tree clumps to torch, or contributing to stand-level, crown-fire behavior.
- A dynamic ecosystems philosophy is a useful foundation for dry-forest management – *an ecologically sustainable mosaic of properly-functioning composition, structure, and density is more important than perpetuation of a particular dry-forest condition in a specific location*.

Figure 48 – Shelterwood seed cut in dry upland forest on Manitou Experimental Forest, Pike National Forest, southern Front Range (Rampart Range), south-central Colorado.

An important objective of dry-forest restoration programs is to reestablish a stand structure similar to an old forest single stratum structural stage (see table 8), which predominated during historical (presettlement) eras (see figs. 34, 44, 45).

Table 5 summarizes these restoration concepts by noting that sustainable dry-forest ecosystems (characterized as an 'ecosystem maintenance stage') would classify as Condition Class 1 when evaluated by using a Fire Regime Condition Class framework.

Table 5 describes composition and structure, tree density, vigor, fire regime, fuel dynamics, and resilience and risk characteristics associated with condition class 1 dry forests.

Although this image shows a regeneration cutting method (shelterwood seed cut), it is illustrative because it shows what a post-treatment, tree-structure outcome might look like for restoration treatments designed to recreate an historical stand structure by emphasizing retention of larger-diameter, older-age ponderosa pine trees.

And, note that this treatment obviously addressed ladder-fuels, but a paucity of smaller trees results in an unbalanced size-class distribution, which may not bode well for the future (especially if bark beetles, pine butterfly, or another disturbance agent affects a high proportion of the overstory-tree cohort).

Note, however, that this image is not necessarily a good example of a comprehensive restoration treatment. Why is this statement true? Because, there is an obvious lack of dead wood, both as down logs and as standing dead trees (snags). A lack of dead wood, and an extreme reduction in surface fuels, was completed for research purposes, not in response to restoration goals and objectives.

Reductions in surface fuel can be important, however, for ensuring overstory-tree survival during subsequent prescribed fire treatments (Fajardo et al. 2007, Hood 2010, Stephens et al. 2012b).

Another example of dry-forest restoration, with an emphasis on restoration of historically appropriate 'old forest single stratum' structure, is the cover image used for this white paper. It shows post-treatment conditions for a restoration project completed in Swan Valley of western Montana.

Note that the Swan Valley image still features an impressive reduction in surface and ladder fuels, but that a minimal component of dead wood was retained in the form of down logs and stem wood pieces containing attached branches.

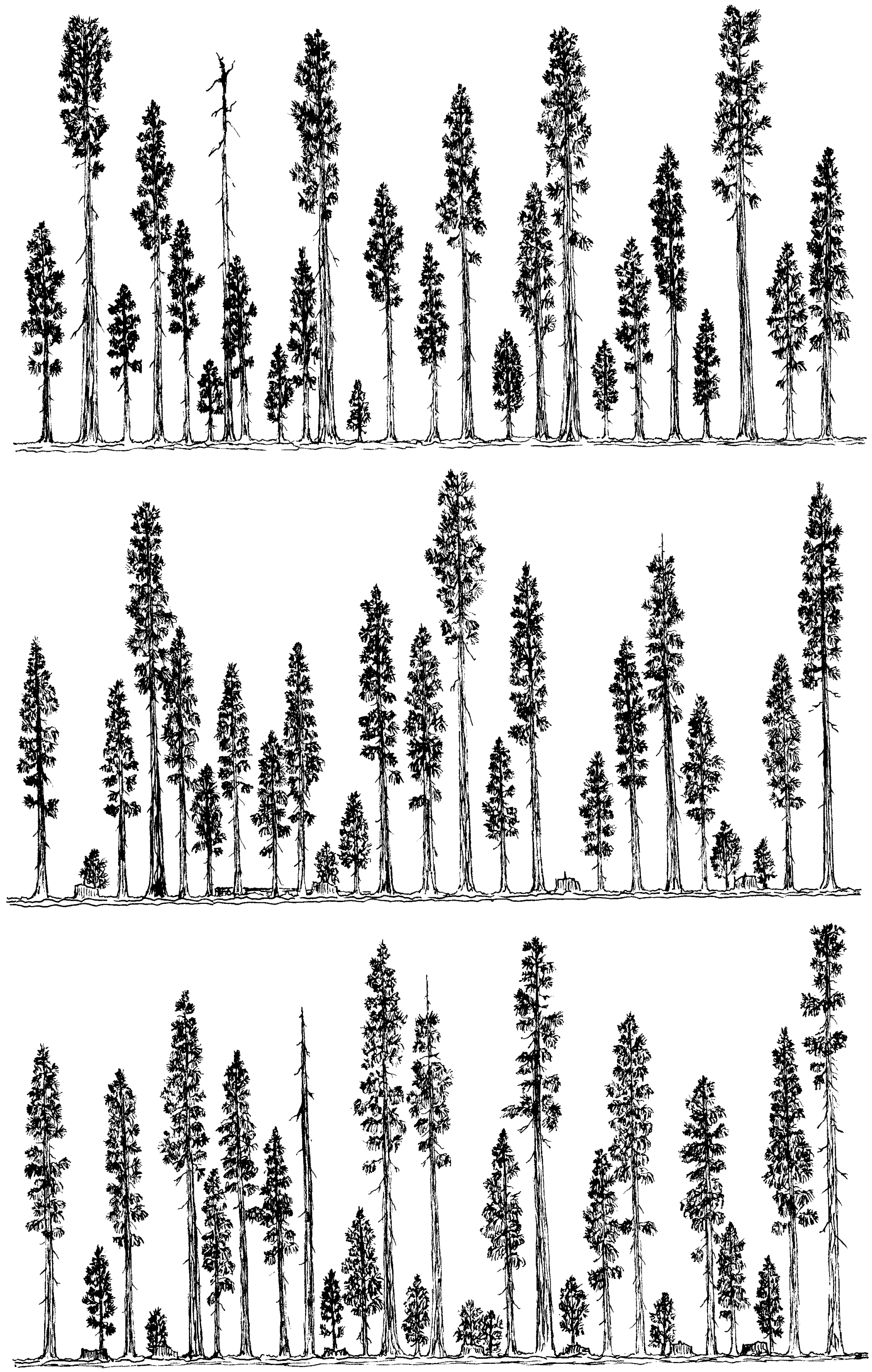


Figure 49 – Application of individual-tree selection in a ponderosa pine forest. An untreated stand (top) has a range of tree sizes. In the first entry (middle), note how four mature trees were removed. A second entry (bottom) continues this cutting intensity. In many respects, *uneven-aged management is ideally suited as a silvicultural system for perpetuating and sustaining dry-forest ecosystems*, while also ensuring that heterogeneous stand structures are provided through time (Franklin et al. 2013).

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IMAGE CREDITS

Unless noted otherwise in a figure caption, color photographs used in this white paper were acquired by David C. Powell. A white-headed woodpecker photograph used in Box 1 was acquired by Al and Elaine Wilson (www.BirdsISaw.com). A panoramic image on page 106 shows a mixed-conifer forest with complex forest structure created by frequent use of prescribed fire in the Illilouette Basin, Yosemite National Park (image taken from North 2012, page 166). Historical, black-and-white photographs are acknowledged in figure captions. Unless noted otherwise, non-photographic charts, diagrams, or graphics were prepared by David C. Powell.

EPILOGUE

Walter C. Lowdermilk, a prominent soil conservationist, led a fascinating life (Helms 1984). Trained as a research forester in Germany and this country, he served in a research capacity for USDA Forest Service in its Southwestern Region and at a Northern Rocky Mountain Research Station in Missoula. While stationed in Montana, he completed studies examining regeneration relationships for Engelmann spruce (Lowdermilk 1925, Lowdermilk and Hamilton 1922).

Lowdermilk completed famine-relief and land-use surveys in China (Lowdermilk and Li 1930), and they tended to show that the country's food security and flooding problems were often related to soil erosion and its detrimental impact on long-term sustainability. And later, after completing runoff and erosion studies in San Dimas watershed of southern California, Lowdermilk was appointed associate Chief for a newly formed USDA Soil Conservation Service.

During an era when society was coming to grips with a Dust Bowl and its implications for agriculture and natural resources (Lowdermilk 1928, 1934), Lowdermilk was asked to survey 'Old World' conditions because any lessons learned could help develop a 'permanent agriculture' for our country. Lowdermilk's trip, occurring in 1938 and 1939, involved Europe, the Mediterranean area and Middle East, and northern Africa.

His 25,000-mile survey of Old World civilizations, and his suppositions about agricultural practices contributing to their downfall (Lowdermilk 1924), caused Lowdermilk to become an 'agricultural archaeologist.' During this work, Lowdermilk was an evangelist about dangers and negative outcomes associated with soil erosion in all its forms.

Lowdermilk's astute and interesting findings were published in one of my favorite sustainability publications: "*Conquest of the Land Through 7,000 Years*" (Lowdermilk 1953). More than a million copies of this bulletin were distributed to American citizens.

Lowdermilk's *Conquest of the Land Through 7,000 Years* offers a possible addition, an eleventh commandment, to original commandments brought down from Mount Sinai (Horeb) by Moses. To my mind, his eleventh commandment touches on several factors influencing sustainability, resilience, and ecological integrity for dry forests.

> "**An Eleventh Commandment: Thou shalt inherit the Holy Earth as a faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever."**

APPENDIX 1: POTENTIAL VEGETATION COMPOSITION

A dry upland forest PVG includes dry mixed-conifer forests occurring in a lower montane vegetation zone (see fig. 3). Portions of three potential vegetation series (see fig. 4) are represented in a dry upland forest PVG – grand fir, ponderosa pine, and Douglas-fir. Note that quaking aspen plant community types, successional (non-climax) stages of a plant association, are also common in the dry upland forest PVG – eight aspen types are included in the list below.

Only three grand fir plant associations are included in a dry upland forest PVG (two 'sod-grass' types: elk sedge and pinegrass associations, and a birchleaf spiraea type), but they occupy substantial acreage in central and southern Blue Mountains. Douglas-fir plant associations are well represented in this potential vegetation group, with Douglas-fir/low shrub types being especially common (snowberry, birchleaf spiraea, and ninebark associations).

Although ponderosa pine is ubiquitous in the Blue Mountains, it is a climax species on a surprisingly small percentage of this area (certainly less than 10% for northern Blue Mountains, but a higher percentage than that for southern Blue Mountains). Many ponderosa pine plant associations were described for the Blue Mountains, and all of them were assigned to this potential vegetation group (Powell et al. 2007), indicating that environmental tolerances of ponderosa pine do not allow it to predominate on cold or moist forest sites.

Table 15: Potential vegetation type (PVT) codes and names, and plant association group (PAG) assignments, for a dry upland forest potential vegetation group (PVG).[1]

PVT Code	PVT Name	PAG
ABGR/CAGE	grand fir/elk sedge	warm dry
ABGR/CARU	grand fir/pinegrass	warm dry
ABGR/SPBE	grand fir/birchleaf spiraea	warm dry
JUSC/CELE	Rocky Mountain juniper/mountain mahogany	warm dry
PIPO/AGSP	ponderosa pine/bluebunch wheatgrass	hot dry
PIPO/ARAR	ponderosa pine/low sagebrush	hot moist
PIPO/ARTRV/CAGE	ponderosa pine/mountain big sagebrush/elk sedge	hot dry
PIPO/ARTRV/FEID-AGSP	pond. pine/mtn. big sage/Idaho fescue-bluebunch wheatgrass	hot dry
PIPO/CAGE	ponderosa pine/elk sedge	warm dry
PIPO/CARU	ponderosa pine/pinegrass	warm dry
PIPO/CELE/CAGE	ponderosa pine/mountain mahogany/elk sedge	warm dry
PIPO/CELE/FEID-AGSP	pond. pine/mtn. mahog./Idaho fescue-bluebunch wheat.	hot dry
PIPO/CELE/PONE	ponderosa pine/mountain mahogany/Wheeler bluegrass	hot dry
PIPO/FEID	ponderosa pine/Idaho fescue	hot dry
PIPO/PERA	ponderosa pine/squaw apple	hot dry
PIPO/PUTR/AGSP	ponderosa pine/bitterbrush/bluebunch wheatgrass	hot dry
PIPO/PUTR/AGSP-POSA	pond. pine/bitterbrush/bluebunch wheat./Sandberg bluegrass	hot dry
PIPO/PUTR/CAGE	ponderosa pine/bitterbrush/elk sedge	warm dry
PIPO/PUTR/CARO	ponderosa pine/bitterbrush/Ross sedge	warm dry
PIPO/PUTR/FEID-AGSP	pond. pine/bitterbrush/Idaho fescue-bluebunch wheat.	hot dry
PIPO/RHGL	ponderosa pine/smooth sumac	hot dry

PVT Code	PVT Name	PAG
PIPO/SPBE	ponderosa pine/birchleaf spiraea	warm dry
PIPO/SYAL	ponderosa pine/common snowberry	warm dry
PIPO/SYOR	ponderosa pine/mountain snowberry	warm dry
PIPO-JUOC/CELE-SYOR	pond. pine/western juniper/mtn. mahog.-mtn. snowberry	hot dry
POTR5/CAGE2	aspen/elk sedge	warm dry
POTR5/CARU	aspen/pinegrass	warm dry
POTR5/EXOTIC GRASS	aspen/exotic grass	warm dry
POTR5/PRVI	aspen/chokecherry	warm dry
POTR5 (RUBBLE, LOW)	aspen (rubble, low)	warm dry
POTR5(ABGR)/SYMPH	aspen(grand fir)/snowberry	warm dry
POTR5(PIPO-PSME)/SYMPH	aspen(ponderosa pine-Douglas-fir)/snowberry	warm dry
POTR5(PSME)/PREM	aspen(Douglas-fir)/bitter cherry	warm dry
PSME/ARNE/CAGE	Douglas-fir/pinemat manzanita/elk sedge	warm dry
PSME/CAGE	Douglas-fir/elk sedge	warm dry
PSME/CARU	Douglas-fir/pinegrass	warm dry
PSME/CELE/CAGE	Douglas-fir/mountain mahogany/elk sedge	warm dry
PSME/PHMA	Douglas-fir/mallow ninebark	warm dry
PSME/SPBE	Douglas-fir/birchleaf spiraea	warm dry
PSME/SYAL	Douglas-fir/common snowberry	warm dry
PSME/SYOR	Douglas-fir/mountain snowberry	warm dry
PSME/SYOR/CAGE	Douglas-fir/mountain snowberry/elk sedge	warm dry
PSME/VAME	Douglas-fir/big huckleberry	warm dry
PSME-PIPO-JUOC/FEID	Douglas-fir/ponderosa pine/western juniper/Idaho fescue	warm dry

[1] Potential vegetation type codes and names, and plant association group assignments, are taken from Powell et al. (2007) except for aspen community types, which are from Swanson et al. (2010).

APPENDIX 2: EARLY 1940S TIMBER HARVEST

This white paper has a section describing selective cutting effects on dry-forest conditions. Light selective cutting occurred in the Blue Mountains as early as late 1800s, and most early harvests involved relatively low timber volumes distributed across fairly small areas. Early mills were small and could easily be moved to a new site (portable circular saws); their locations changed frequently as available timber was depleted. Many early mills were located along streams because they depended on water power to run a circular saw.

By 1920s, high-volume sales covering large areas were awarded. Oregon Lumber Company built a sawmill at Bates (a town-site located near Oregon Highway 7 about 15 miles northeast of Prairie City) after it was awarded a 124 million board foot timber sale in Middle Fork of John Day River drainage (USDA Forest Service 1916). Another example is a Camas Creek sale containing 221.3 million board feet of national forest timber on Umatilla National Forest. It covered an area of about 69,645 acres in the Camas and Meadow Creek watersheds (North Fork John Day Ranger District); western boundary of this unit was located app. 10 miles east of Ukiah, Oregon.

Timber on the Camas Creek unit consisted of a mixed stand of ponderosa pine, Douglas-fir, western larch, lodgepole pine, and other species (Matz 1932). All advertised volume was ponderosa pine; cutting of other 'inferior' species (Neff 1928, Starker 1915) was optional at the discretion of a purchaser (Stevenson 1937).

Calculations in a timber appraisal showed that sustained yield for Camas Creek block was 13,780,000 board feet per year, so the Camas Creek timber sale represented an 'over-cut' of 71,100,000 board feet for a five-year period (USDA Forest Service 1938).

Blue Mountain harvest levels escalated in 1928 when Edward Hines Lumber Company was awarded a long-term contract for 890 million board feet in Seneca area (USDA Forest Service 1922). This enormous timber sale, called the Bear Valley Unit, provides a good example of timber being not only a commodity, but also a federal government tool for community development (Fedkiw 1999). As of late 1920s, Bear Valley timber sale was the largest ever offered in Pacific Northwest, and it was probably more widely advertised throughout the United States than any other sale of national forest timber up to that point in time.

Bear Valley timber sale was designed to extend Oregon Short Line Railroad from Crane to Burns (30 miles of standard-gauge track), extend the railroad farther by running lines from Burns to Seneca (50 miles), and then develop short branch lines from Seneca into timber sale areas in headwaters of Silvies River. Railroad work associated with Bear Valley sale had an influence on the broader Blue Mountains area. Construction of Oregon Short Line connecting Oregon-Washington Railroad and Navigation Company with Union Pacific Railroad allowed eastern Oregon to enter national lumber markets for the first time. Prior to this railroad development, all pine lumber produced in the Blue Mountains was used for local or regional consumption.

Photographs in this appendix were taken on Bear Valley Unit as it was being operated by Hines Lumber Company. Photographer was Russell Lee, who worked for the federal government as an employee of Farm Security Administration. Photographs were taken from this website: http://photogrammar.yale.edu/

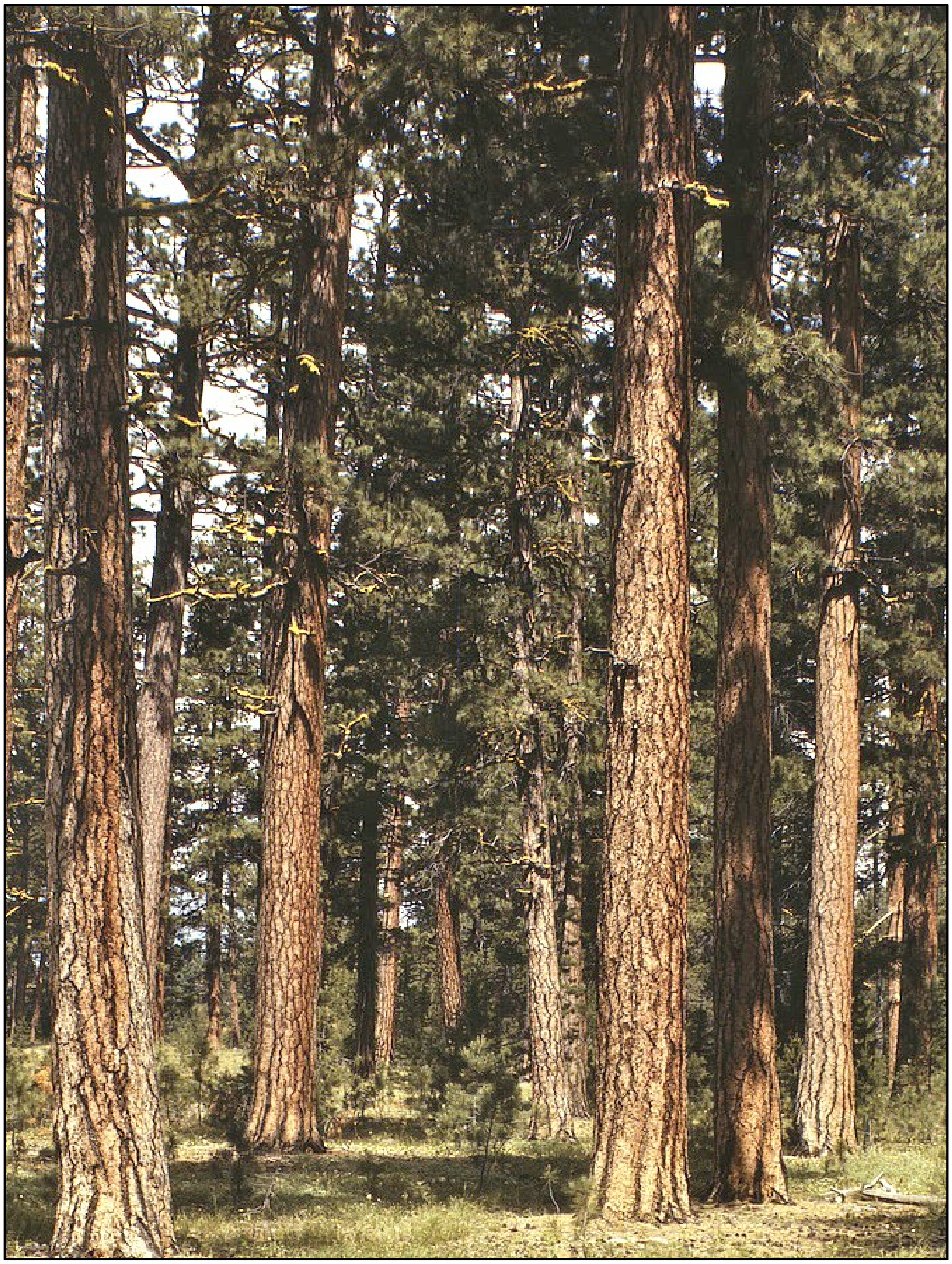

Figure 50 – Virgin (unmanaged) ponderosa pine forest in Grant County, Oregon (photo by Russell Lee, July 1942). [This image depicts better-than-average conditions in terms of stocking levels; it is known that photographers tended to select the best examples.] This image shows a mature stand of ponderosa pine, with closely-spaced groups or clumps of large-diameter trees. Note that spindly, suppressed ponderosa pine seedlings are also present as an understory.

A paradigm of this era was to remove mature and overmature ponderosa pines before they were attacked by western pine beetle. Maturity selection methods were used to evaluate tree vigor and insect susceptibility, particularly involving methods developed by F.P. Keen (1936, 1950), and thereby identify old pines with high susceptibility to western pine beetle attack.

Figure 51 – Forest Service official designating (marking) a tree for removal in Grant County, Oregon (photo by Russell Lee, July 1942). [Note a soft, fedora-style 'hardhat' worn by this Forest Service official.] Even though a high-volume timber sale occurring across a wide area had been awarded to Edward Hines Lumber Company (USDA Forest Service 1922), Forest Service still needed to designate trees for removal before they could be felled.

In this era and for these large sales, it was common to have a Forest Service official assigned to a sale operation full-time, and he might mark trees in the morning that were felled later that same day by a purchaser's timber fallers. This strategy differs from contemporary practice because USDA Forest Service now completes timber designation activities well in advance of awarding a timber sale to a successful purchaser.

Here is a description of how early marking occurred: "The mechanical part of marking consists simply of striking a clean-surfaced bark blaze at breast or shoulder height with a keen-bladed special hatchet and stamping on this with the head of the hatchet the letters 'U.S.' This operation is repeated on the base of the tree below stump height. Whether a man is fast at this job, which may be a big and time-consuming job on a large sale, depends upon several things. He will be slow unless his judgment is such as to enable him to weigh all the factors and make his decision as fast as he can get to the trees, if he is either lazy or physically unfit for hard work, or if he does not avoid lost motion in getting around to his timber" (Perry 1999, p. 97).

Walt Perry went on to describe how he was able to mark more than 1,000 trees in an 8-hour workday by using this method, and he bragged that on one day, he marked 1,685 trees in only 7 hours and 50 minutes (suggesting that on some days, at least, quantity was placed at a higher premium than quality when it came to tree marking).

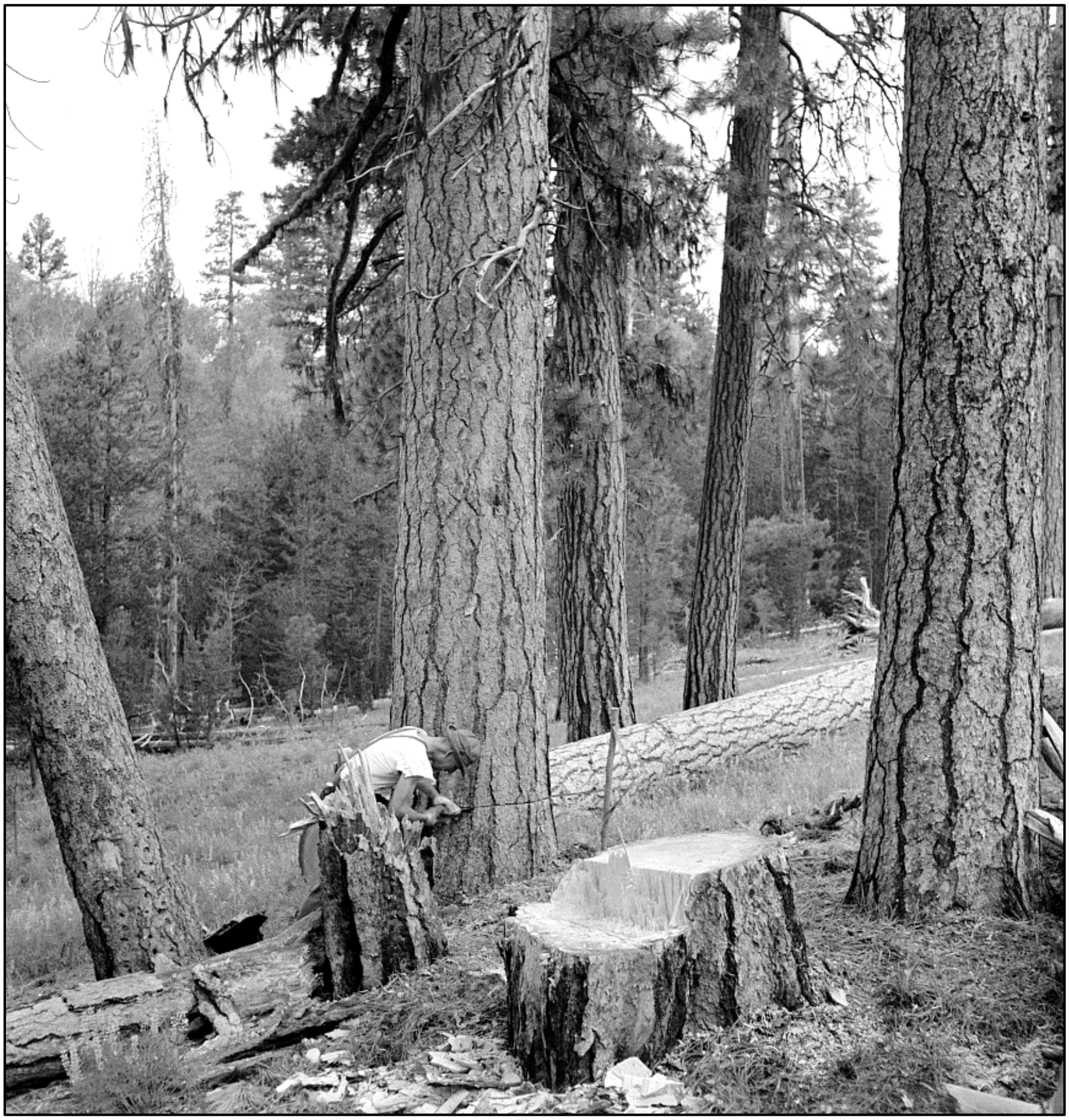

Figure 52 – Falling a large ponderosa pine with a crosscut saw in Grant County, Oregon (photo by Russell Lee, July 1942). When these photographs were taken, all tree falling operations were accomplished by using crosscut saws, commonly referred to as 'misery whips' because of the human effort involved in their use. Optimum productivity was obtained by having fallers work in pairs so they could operate a crosscut saw in tandem.

Through the early 1960s, most timber harvest in the Blue Mountains involved ponderosa pine removals, and it included predominantly large-diameter trees: "At the present time, most of the timber cut is from trees 30 inches d.b.h. and larger. For ponderosa pine, 83 percent of the present cut comes from trees over 30 inches d.b.h." (Gedney 1963: p. 47).

Trees being felled in this photograph are ponderosa pine, and all of them appear to be 30 inches d.b.h. or larger. Most photographs in this appendix depict the same situation.

Figure 53 – Falling a large ponderosa pine by using a crosscut saw and a 'rubber-man' setup in Grant County, Oregon (photo by Russell Lee, July 1942). In this situation, a single faller could work a tree by driving a stout stake in the ground, and then attaching strips of rubber inner tube to the stake and one end of a saw. A faller would pull the saw, and a 'rubber-man' would pull it back.

This setup was often used when there weren't enough fallers to form only two-man teams, when a faller wanted to work alone to collect extra wages, or to avoid unwanted back-talk from a partner.

Often, fallers who used rubber-man setups frequently, because they preferred to work alone, would attach their rubber strips to an iron stake instead of a wood stake, as metal tended to be more rigid and durable.

Figure 54 – Setting a choker cable on a large pine log in Grant County, Oregon (photo by Russell Lee, July 1942). This image shows very large size associated with centuries-old ponderosa pines being removed from Bear Valley Unit by Edward Hines Lumber Company.

When considering the high wood quality shown here, it's a little sad to realize that many of these trees were used to make what might be viewed, now, as lower-value products, such as shipping boxes for apples, cherries, and other fruit from Yakima, Walla Walla, and Hood River valleys.

Figure 55 – Yarding ponderosa pine logs after they were felled and bucked into merchantable lengths; Grant County, Oregon (photo by Russell Lee, July 1942). During this era, crawler tractors were commonly used to haul bucked logs to a collection point where a larger tractor would then skid them to a loader (fig. 56). It was subsequently learned, however, that crawler tractors often caused unacceptable levels of soil compaction (Froehlich and McNabb 1984), depending on soil type, soil moisture, and other factors.

Note that the surrounding stand contains some tree species other than ponderosa pine, although sale contracts of this era typically did not require removal of tree species other than ponderosa pine, or removal of these 'other species' was at discretion of a purchaser.

Subsequent forest stand dynamics research showed that leaving what was commonly referred to as 'inferior species' on dry-forest sites (Neff 1928, Starker 1915) contributed to compositional shifts that eventually resulted in substantial defoliation impacts during western spruce budworm and Douglas-fir tussock moth outbreaks, two insect defoliators that historically played minor roles on dry-forest sites when they were dominated by ponderosa pine instead of Douglas-fir and grand fir (Powell 1994, Williams 1978, Williams et al. 1980).

Figure 56 – Skidding logs to a loader in Grant County, Oregon (photo by Russell Lee, July 1942). As noted for figure 55, this photo depicts a surrounding stand containing tree species other than ponderosa pine. In fact, the tractor is approaching a western larch on its right side with dwarf mistletoe infection in its lower branches.

Note high levels of soil disturbance associated with these major skid trail routes.

Figure 57 – Loading ponderosa pine logs on a truck for transport to a mill yard in Grant County, Oregon (photo by Russell Lee, July 1942). After a large crawler tractor delivers its load of logs to a loading area (fig. 56), a boom-type loader lifts them up and swings them over to a log trailer, where they are added to a load in preparation for transport to a mill yard in town.

Once again, note a mixed-species composition for the background forest stand, and a high level of soil disturbance in the foreground scene.

Figure 58 – A full load of large ponderosa pine logs before being transported to a mill yard in Grant County, Oregon (photo by Russell Lee, July 1942). Mills of this era used large circular saws designed specifically to process large-diameter logs, and logs shown in this image were typical for timber sales up through the late 1980s.

These logs were an important raw material for lumber mills operating in small communities throughout the Blue Mountains. In mid to late 1950s, almost every community in the Blue Mountains supported at least one sawmill, including communities as small as Troy, Oregon.

It may be hard to believe when considering contemporary conditions, but in eastern Oregon, 49 communities had timber-processing mills in mid to late 1950s – 33 communities had one mill, 10 communities had two mills, and 6 communities had three or more mills (Gedney 1963).

By 1972, the number of wood processing mills for Oregon portion of Blue Mountains area (Baker, Grant, Harney, Malheur, Morrow, Umatilla, Union, and Wallowa counties) had fallen to 30, including 23 lumber mills, 4 veneer and plywood plants, 2 pulp and board mills, and 1 shake and shingle mill (Bolsinger and Berger 1975: p. 11).

Figure 59 – Loading large ponderosa pine logs onto railroad cars in Baker County (photo by Russell Lee, 1941). As noted at the beginning of this appendix, railroad logging was not uncommon in the Blue Mountains, particularly in association with high-volume timber sales such as Bear Valley Unit (USDA Forest Service 1922).

Most logging railroads (and they were plentiful) were narrow-gauge, although track and ties have now been removed, and little evidence generally remains of their existence, other than an abandoned rail bed. Note, however, that some old rail beds have been incorporated into a 'rails to trails' recreation system.

APPENDIX 3: REGENERATION MONITORING RESULTS

This appendix provides regeneration monitoring results for dry upland forests of Umatilla National Forest (table 16). It summarizes tree density (stems per acre), by species as grouped by seral status, for 76 plots established in plantations located on a Dry Upland Forest potential vegetation group (71 plots are Managed Stand Survey installations; 5 plots were established during a Forest Plan review of regeneration results). Sources/Notes section at end of table 16 provides additional information about origin of this data.

Plots are grouped hierarchically – first by plant association (mean values are provided for each association), and second by potential vegetation group (mean values are provided for a Dry Upland Forest PVG overall).

This table provides monitoring information to inform dry-forest prescriptions for tree planting (reforestation). Planting is a high-cost activity (fig. 60) in a vegetation management realm – when considering both internal costs (contract administration, seed procurement, etc.) and external costs (service contract for out-planting, seedling procurement, etc.), total planting cost often runs from $300 to $500 per acre.

As budgetary resources continue to decline, land managers must consider reforestation options that could be implemented at lower cost. Regeneration monitoring data presented in this appendix demonstrates that dry-forest sites tend to support abundant amounts of natural regeneration, and that much of this regeneration has relatively high levels of species diversity.

When considering a Dry Upland Forest PVG in its entirety (see "Mean: Dry Upland Forest PVG" row at bottom of table 16), pines have high average density levels (ponderosa pine averages 243 stems per acre and lodgepole pine averages 138 stems per acre). Relatively high amounts of Douglas-fir and grand fir regeneration are also present (180 stems per acre for grand fir and 143 stems per acre for Douglas-fir), which is not surprising because seed rain for these species is known to be up to an order of magnitude higher than for pines, larch, and other early-seral tree species (Zald et al. 2008). Therefore, 'fir be gone' prescriptions designed to specifically reduce (but not eliminate) representation of Douglas-fir and grand fir are justified somewhat as a counterbalance to their regeneration proficiency (and see appendix 4 for more on this issue).

National Forest Management Act of 1976 (P.L. 94-588) (NFMA) states that when trees are cut to achieve timber production objectives, cuttings shall be made in such a way that "there is assurance that such lands can be adequately restocked within 5 years after harvest" (sec. 6, (g), (3), (E), (ii)). This statement has been interpreted in various ways, but it does not mean that reforestation (tree planting) must occur within 5 years of timber harvest (Watrud et al. 2012).

A NFMA passage quoted above uses the word 'assurance' when describing a 5-year regeneration requirement. The Washington Office has interpreted 'assurance' to mean that we must use our best efforts and best judgment to assure that restocking occurs within five years. Other interpretations of NFMA language suggest that regeneration cutting should not be prescribed for areas where previous experience suggests that restocking will likely not occur in 5 years, regardless of whether stocking is derived from natural regeneration, tree planting, or both.

Figure 60 – Reforestation following severe fire effects. Dry-forest sites that experience wildfire with uncharacteristic fire behavior for fire regime I (crown fire) tend to end up with uncharacteristic fire effects, such as complete overstory-tree mortality (stand-replacing fire severity), volatized litter and duff layers, and so forth.

This image shows a second-growth ponderosa pine stand (which likely originated as a plantation decades ago) that burned with high severity, resulting in total mortality of overstory trees.

Reforestation is a costly forest management activity, with total cost often exceeding $500 per acre when all costs are considered: seed collection and storage, contract preparation and administration, out-planting contract costs, post-planting survival and growth monitoring, animal damage control, and indirect costs (overhead).

When a dry-forest, fire-regime-I site burns with uncharacteristic fire severity, the post-fire environment can present especially harsh reforestation conditions. One response to this situation is to use shadecards for planted seedlings. This image shows shadecards being used to compensate for a lack of overhead shade from surviving overstory trees.

[Note that some folks who view this image react as though it depicts Arlington National Cemetery, as might be suggested by the white markers. Depending on seedling survival rates, perhaps the Arlington Cemetery analogy is an apt one.]

Regardless of one's reaction to this image, mitigation measures such as shadecards are likely to become more common (along with their attendant costs) in a climate-changed future featuring up to 6 times more wildfire than we've been used to in the past (fig. 40), along with a potentially greater proportion of high-severity fire than historically.

An interest in prompt reforestation following harvest is also expressed in other language from NFMA: "Sec. 3 (d) (1) It is the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans."

USDA Forest Service has defined appropriate forest cover as "vegetation composed of plant communities, which would occur naturally on similar sites depending upon the stage of plant succession. Forbs, grasses, and shrubs in their proper ratios are also elements of forest cover" (FSM 2470, section 2472.05 – Definitions). This interpretation of appropriate forest cover is well aligned with recent science findings highlighting the ecological importance of early-successional stages (Swanson et al. 2011).

I recommend that tree planting be considered as a post-harvest activity for dry upland forests receiving a regeneration cutting treatment, and I also recommend that a planting decision be informed by regeneration monitoring results presented in table 16. Table 16 data suggests that natural regeneration is often abundant for dry upland forest sites, but much of it is comprised of mid- or late-seral tree species. Therefore, tree planting could be prescribed to establish an ecologically appropriate forest cover, including an appropriate mix of early-seral tree species in the context of an early stage of plant succession (Swanson et al. 2011).

Forest Vegetation Simulator (FVS) Regeration Modeling Considerations

None of the Pacific Northwest variants of FVS include a regeneration establishment model. If they did, FVS would periodically interject 'background' levels of natural regeneration (e.g., ingrowth), and composition and amounts of regeneration would vary with a stand's plant association code (e.g., assumptions about periodic ingrowth would vary by plant association).

For most areas of Pacific Northwest, relatively high levels of background ingrowth are a fact of life, and they should be reflected in growth-and-yield simulations. Since the Blue Mountains variant of FVS is not interjecting ingrowth automatically, users need to add it manually by invoking either 'natural' or 'plant' keywords. Regeneration monitoring results presented in this appendix provide a reasonable basis for formulating credible ingrowth scenarios for dry upland forests of northern Blue Mountains (Umatilla National Forest).

[Note: A Managed Stand Survey (MSS) inventory process was initiated in late 1980s. Initial installations (1-acre plots) were installed in young, managed stands throughout the Pacific Northwest Region. One reason for initiating an MSS program was to obtain long-term information about ingrowth and young-stand development, and then use it to calibrate FVS and develop variant-specific regeneration establishment models. Unfortunately, MSS plots were never remeasured, so they could not provide long-term trend data suitable for making FVS revisions.]

Table 16: Regeneration monitoring results for dry upland forests of the Umatilla National Forest.

Plot	Plant Association	PAG	WJ	PP	LP	WL	Early Seral	DF	WP	Mid Seral	ES	GF	SF	Late Seral	Other Spp	Total
			<—————————— All values in these columns are Trees per Acre ——————————>													
2012	DF/CAGE	WD		84			84	80		80						164
2259	DF/CAGE	WD		147			147	217		217		100		100		464
2508	DF/CAGE	WD		105			105	8		8						113
2513	DF/CAGE	WD		144			144	64		64		44		44		252
2515	DF/CAGE	WD		189			189	72		72						261
2527	DF/CAGE	WD		88	425		513	61		61		4		4		578
2531	DF/CAGE	WD		27			27	44		44		20		20		91
2780	DF/CAGE	WD		108			108	68		68		4		4		180
	Mean: DF/CAGE			112	425		165	77		77		34		34		263
2003	DF/CARU	WD		36		4	40	131		131		584		584		755
2807	DF/CARU	WD		99			99	475		475		8		8		582
2809	DF/CARU	WD		4		40	44	111		111		61		61		216
2815	DF/CARU	WD		291		8	299	163		163		80		80		542
	Mean: DF/CARU			108		17	121	220		220		183		183		524
2808	DF/PHMA	WD		8		7	15	311		311		4		4		330
UMA15	DF/PHMA	WD		170			170	10		10						180
	Mean: DF/PHMA			89		7	93	161		161		4		4		255
2020	DF/SYAL	WD	93	51			144	108		108						252
2806	DF/SYAL	WD		15		7	22	167		167		80		80		269
2836	DF/SYAL	WD		4		8	12	200		200		60		60	20	292
UMA3	DF/SYAL	WD		155		10	165	10		10						175
UMA8	DF/SYAL	WD		840		30	870	60		60						930
	Mean: DF/SYAL		93	213		14	243	109		109		70		70	20	384
2514	DF/VAME	WD		1623			1623									1623
2005	GF/CAGE	WD			100	60	160	367		367		20		20		547

Plot	Plant Association	PAG	WJ	PP	LP	WL	Early Seral	DF	WP	Mid Seral	ES	GF	SF	Late Seral	Other Spp	Total
			<———————— All values in these columns are Trees per Acre ————————>													
2009	GF/CARU	WD	20	569		420	1009	20		20		504		504		1533
2015	GF/CARU	WD		147	20	4	171	52		52		251		251		474
2016	GF/CARU	WD		36	20		56	156		156		164		164		376
2250	GF/CARU	WD		465			465	179		179		104		104		748
2251	GF/CARU	WD		63		35	98	121		121		315		315		534
2260	GF/CARU	WD		335		4	339	12		12	20	100		120		471
2503	GF/CARU	WD		360	235	32	627	1180		1180		553	40	593		2400
2528	GF/CARU	WD		628	165	701	1494	373		373		1069	100	1169		3036
2813	GF/CARU	WD		117		4	121	111		111		317		317		549
2823	GF/CARU	WD		519		4	523	439		439		160		160		1122
UMA4	GF/CARU	WD		195			195	145		145		80		80		420
	Mean: GF/CARU		20	312	110	151	463	253		253	20	329	70	343		1060
2772	GF/SPBE	WD		139			139	120		120		28		28		287
2810	GF/SPBE	WD		11		7	18	240		240		1037		1037		1295
2814	GF/SPBE	WD		31		4	35	229		229		87		87		351
2831	GF/SPBE	WD						69		69		92		92		161
UMA5	GF/SPBE	WD		80		190	270	390		390		170		170		830
	Mean: GF/SPBE			65		67	116	210		210		283		283		585
2023	PP/AGSP	HD	100	139			239									239
2779	PP/AGSP	HD		159			159	12		12						171
	Mean: PP/AGSP		100	149			199	12		12						205
2000	PP/CAGE	WD	20	99			119	24		24	143	167	167	477		620
2002	PP/CAGE	WD	228	203			431	11		11						442
2013	PP/CAGE	WD	104	191			295									295
2022	PP/CAGE	WD	80	600			680									680
2502	PP/CAGE	WD		225			225	92		92						317
2505	PP/CAGE	WD		140			140	100		100						240
2509	PP/CAGE	WD		163			163	4		4		20		20		187

Plot	Plant Association	PAG	WJ	PP	LP	WL	Early Seral	DF	WP	Mid Seral	ES	GF	SF	Late Seral	Other Spp	Total
			<——————————— All values in these columns are Trees per Acre ———————————>													
2511	PP/CAGE	WD		1072			1072	67		67		24		24		1163
2520	PP/CAGE	WD		120			120	4		4						124
2523	PP/CAGE	WD		117			117									117
2525	PP/CAGE	WD		1025		4	1029	20		20		51		51		1100
2536	PP/CAGE	WD		765		100	865	44		44						909
	Mean: PP/CAGE		108	393		52	438	41		41	143	66	167	143		516
2519	PP/CARU	WD		233			233									233
2522	PP/CARU	WD		205	4		209	8		8						217
2534	PP/CARU	WD		172			172									172
	Mean: PP/CARU			203	4		205	8		8						207
2521	PP/CELE/CAGE	WD		173			173	20		20						193
2510	PP/CELE/FEID-AGSP	HD		1020			1020	68		68		20		20		1108
2524	PP/CELE/FEID-AGSP	HD		40			40									40
	Mean: PP/CELE/FEID-AGSP			530			530	68		68		20		20		574
2001	PP/FEID	HD	64	301			365									365
2006	PP/FEID	HD	160	71			231	40		40						271
2007	PP/FEID	HD	20	188			208									208
2014	PP/FEID	HD	40	307			347	120		120						467
2021	PP/FEID	HD	44	199			243									243
2252	PP/FEID	HD		147			147	7		7						154
2253	PP/FEID	HD		12			12	4		4						16
2500	PP/FEID	HD		139			139	101		101						240
2501	PP/FEID	HD	4	64			68	4		4						72
2506	PP/FEID	HD	44	75			119									119
2526	PP/FEID	HD		304			304	40		40						344
2535	PP/FEID	HD		92			92									92
	Mean: PP/FEID		54	158			190	45		45						216

Plot	Plant Association	PAG	WJ	PP	LP	WL	Early Seral	DF	WP	Mid Seral	ES	GF	SF	Late Seral	Other Spp	Total
			<——————————— All values in these columns are Trees per Acre ———————————>													
2008	PP/SYAL	WD	60	253			313	1041		1041		60		60		1414
2018	PP/SYAL	WD	100	168			268									268
2255	PP/SYAL	WD		359			359	440		440						799
2804	PP/SYAL	WD		109			109	16		16						125
2805	PP/SYAL	WD		185			185	7		7		20		20		212
2811	PP/SYAL	WD		132			132	8		8						140
2812	PP/SYAL	WD		116			116	8		8						124
	Mean: PP/SYAL		80	189			212	253		253		40		40		440
Mean: Dry Upland Forest PVG			74	243	138	77	291	143		143	82	180	102	193	20	495

Sources/Notes: **Plot** includes two types of plots: numbers refer to plots from a Managed Stand Survey (MSS), a plot-based system (5-point plot cluster covering about 1 acre) installed in 1990 in young, managed stands with an average stand diameter of 3 inches or more. Plots beginning with UMA were part of a Forest-wide reforestation monitoring effort completed in 1994 (16 plots installed in randomly selected reforestation units across the Umatilla National Forest; see Powell 1995). **Plant association** is an acronym formed from a 2-digit tree species (DF = Douglas-fir; GF = grand fir; PP = ponderosa pine) and a 4- or 5-digit understory species code (AGSP = bluebunch wheatgrass; CAGE = elk sedge; CARU = pinegrass; CELE = mountain mahogany; FEID = Idaho fescue; PHMA = mallow ninebark; SPBE = birchleaf spiraea; SYAL = common snowberry; VAME = big huckleberry). **PAG** refers to plant association group (WD is warm dry; HD is hot dry; see Powell et al. 2007). Columns are provided for individual tree species (in addition to species codes already mentioned, WJ = western juniper; PP = ponderosa pine; LP = lodgepole pine; WL = western larch; DF = Douglas-fir; WP = western white pine; ES = Engelmann spruce). **Early Seral** is a sum of preceding four species columns; **Mid Seral** is a sum of preceding two columns; **Late Seral** is a sum of preceding three columns; other species (Spp) includes Pacific yew, hawthorn, willow, and paper birch. **Total** is a summed tree density value, as trees per acre, for all individual species columns.

Note: tree density values include total tree stocking, including three categories of trees: (1) trees established by out-planting (e.g., trees originating as nursery-produced seedlings), (2) trees established as natural regeneration (trees originating from natural seeding occurring after timber harvest or another disturbance), and (3) trees present before a disturbance process (including 'advance' regeneration and mature trees from a previous stand that survived the disturbance process).

Mean values are presented for each plant association, and at the bottom of this table for Dry Upland Forest PVG as a whole. They were calculated in such a way that plots where a tree species or seral stage did not occur (there is a blank in the species or seral stage column) were not included in the calculation (in other words, blanks were not treated as zero values when calculating Means).

APPENDIX 4: REDUCING DOUGLAS-FIR AND GRAND FIR REPRESENTATION ON DRY-FOREST SITES

This white paper describes how historical (and ongoing) programs contribute to increased representation of Douglas-fir and grand fir on dry-forest sites. Fire suppression, livestock grazing, and selective cutting resulted in more Douglas-fir and grand fir trees being present now than would have been seen by Oregon Trail pioneers when they crossed the Blue Mountains during the mid to late 1800s (Beckham 1991, Evans 1991, Fremont 1845).

What qualifies as an ecologically 'correct' representation of Douglas-fir and grand fir for dry-forest sites? Responses to this question should consider two contexts – a landscape scale (e.g., what proportion of a dry-forest landscape should consist of Douglas-fir or grand fir patches, cover types, or stands?), and a stand scale (i.e., how much of the species composition for a typical dry-forest site (stand or patch) should consist of Douglas-fir or grand fir?).

Section 7.9 of this white paper, *Range of Variation as a Restoration Framework*, provides information to answer the landscape-scale question. Historically, Douglas-fir cover types (stands), in aggregate, occupied 5-20% of dry-forest landscapes, and grand fir cover types (stands) were found on no more than 1-10% of dry-forest acreage (see table 9).

Section 7.4 of this white paper, *Desired Conditions for Dry-Forest Sites*, provides information to answer the stand-scale question. Historically, the most common cover type for dry-forest landscapes was ponderosa pine (50-80% of these areas was ponderosa pine; see table 9). This means that more than half the time, dry-forest stands were dominated by ponderosa pine, with limited amounts of other species – *up to 70% of their composition consisted of ponderosa pine, and no more than 30% was comprised of Douglas-fir, grand fir, or other species* (see sec. 7.4).

Because Douglas-fir and grand fir cover types (stands) are commonly over-represented on dry-forest landscapes (fig. 38 describes 'over-represented' and 'under-represented' in a range of variation context), and because Douglas-fir and grand fir are often over-represented in the composition of any typical dry-forest polygon (stand), *silvicultural prescriptions and marking guides should attempt to reduce representation of Douglas-fir and grand fir when doing so is compatible with a project area's goals, objectives, and desired future conditions*.

PNW Region (R-6) silviculturists have tools for reducing representation of small-diameter Douglas-firs and grand firs. Tools relating to timber harvest, however, are limited for addressing large-diameter (≥ 21" dbh) but young (< 150 years abh) Douglas-firs and grand firs – and these limitations primarily relate to management direction called the Eastside Screens.

This appendix provides concepts and rationale for amending the wildlife portion of Eastside Screens (including its Scenario A) to address the fact that grand fir and Douglas-fir are over-represented (too plentiful) on dry-forest sites in comparison to historical conditions.

Eastside Screens, a Regional Forester's Forest Plan amendment (USDA Forest Service 1995), amended all Forest Plans for national forests in eastern Oregon and eastern Washington. The Screens have gone through several iterations since their issuance as interim direction in 1993.

As described earlier, much of the dry-forest landscape is overstocked, and in need of thinning to help restore forest health and wildfire resilience. An analysis showed that a 21-inch diameter limit (as required by the Eastside Screens) functions as an obvious constraint when attempting to complete these thinning treatments (Barbour et al. 2008).

In 2003, 10 years after Screens implementation, Pacific Northwest Region's Regional Forester assessed whether the Eastside Screens were functioning as intended (Goodman 2003):

"Practical experience in trying to meet these objectives, however, has sometimes presented challenges. A recent survey of eastside Forest Silviculturists revealed that the interpretation of screens direction, including 21-inch diameter limitations, no harvest in stands below HRV (Scenario A), and prescriptive connectivity corridors, is limiting their ability to meet the screens objectives of providing LOS stands – particularly drier LOS single-story ponderosa pine or western larch stands.

I therefore encourage you to consider site-specific Forest Plan amendments where this will better meet LOS objectives by moving the landscape towards HRV, and providing LOS for habitat needs of associated wildlife species. [Memo mentions pygmy nuthatch, white-headed woodpecker, pileated woodpecker, and flammulated owl as wildlife species of particular concern.]

The enclosure [to the letter] provides examples of when this may be appropriate. The objective of increasing the number of large trees and LOS stands on the landscape remains. Economic considerations are important but are not considered adequate justification alone for conducting harvest activities in LOS stands" (Goodman 2003).

Concepts and principles presented in this appendix respond primarily to Goodman's concerns about a 21-inch diameter limitation. Discussion tiers closely to two recent sources:

Restoration of Dry Forests in Eastern Oregon: A Field Guide (Franklin et al. 2013).

Identifying Old Trees and Forests in Eastern Washington (Van Pelt 2008).

In my view, material presented here is often consistent with restoration guidance from eastern Oregon's conservation community – ***Restoring Eastern Oregon's Dry Forests: A Practical Guide for Ecological Restoration*** (Lillebo 2012), ***Thinning Certain Oregon Forests to Restore Ecological Function*** (Kerr 2007), and ***Thinning, Fire, and Forest Restoration*** (Brown 2002).

As described in appendix 3, *Regeneration Monitoring Results*, increased representation of grand fir and Douglas-fir on dry-forest sites results from greater amounts of seed rain for both these species and, as a consequence, their numbers continue to increase at accelerating rates.

Because an uncharacteristically high proportion of dry-forest species composition now consists of Douglas-fir and grand fir, a positive feedback loop has been formed – both species produce regular and frequent seed crops, and regeneration for both of them develop better in shaded, high-density conditions than ponderosa pine, so natural tree regeneration on dry sites is increasingly dominated by Douglas-fir and grand fir, not by ponderosa pine.

This appendix presents a rationale for removing certain Douglas-fir and grand fir trees when designing dry-forest treatments involving timber harvest:

Douglas-fir and grand fir trees that are ≥ 21" dbh (diameter at breast height), but are less

than 150 years abh (age at breast height) and located within a 2-dripline distance of a desirable tree, should be evaluated for removal when planning timber harvest activities.

[Note: Trees < 150 years abh and ≥ 21″ dbh are not the only Douglas-fir and grand fir individuals that should be considered for removal, but currently they are not evaluated for removal due to an Eastside Screens Forest Plan amendment.]

Defining Desirable Trees for a Dry-Forest Context

This section describes a rationale for removal of young (less than 150 years abh) grand fir and Douglas-fir trees that are over 21″ dbh and interacting with a desirable tree. Much of the rationale is derived from a recent science guide recommending management approaches for dry forests in eastern Oregon (Franklin et al. 2013).

A desirable tree is defined as any tree whose retention would contribute to desired conditions for dry-forest sites; for the context of this white paper, desired conditions are described in section 7.4: *Desired Conditions for Dry-Forest Sites*.

Desirable trees include the following species preference (from most desirable to least desirable): any live tree ≥ 21″ dbh and ≥ 150 years abh, ponderosa pine, western larch, Douglas-fir, [Engelmann spruce], grand fir, [lodgepole pine], and western juniper. On dry-forest sites, tree species in brackets are uncommon, and they are typically associated only with seeps and other moist microsites. *A desirable tree also possesses a vigor level, and a lack of insect or disease activity, suggesting it could survive for at least 10 more years*.

Occasionally, a desirable tree is ≥ 150 years abh but < 21″ dbh. For these situations, young but large grand fir and Douglas-fir trees (e.g., grand fir and Douglas-fir trees < 150 years abh and ≥ 21″ dbh) should be considered for removal from within a distance equal to or less than 2 driplines (twice the dripline distance) from a tree greater than 150 years abh, but less than 21″ dbh, when it qualifies as desirable (possible examples: a 16" dbh ponderosa pine, or a 15" dbh western larch, that is ≥ 150 years abh). *In general, I recommend that old trees (≥ 150 years abh) be excluded from timber harvest, regardless of species* (Blicharska and Mikusinski 2014).

“Restoring species composition towards historical levels can often mean removing large but younger (<150 year) grand/white fir and Douglas-fir to favor pines and western larch. Hard diameter limits, such as a 21-inch dbh limit, can make it difficult or impossible to achieve desired composition in many Mixed-Conifer Forests, which would compromise their future resilience” (Franklin et al. 2013: 74).

The above quote is taken from “Restoration of dry forests in eastern Oregon: A field guide,” authored by Jerry Franklin and others (published in July 2013 by Nature Conservancy; 202 p.).

It is expected that this dry-forest restoration guide (Franklin et al. 2013) will be used to inform ongoing and future planning efforts for dry-forest ecosystems, particularly because influential eastern Oregon stakeholders were involved in the guide’s development, and many of them continue to actively participate in dry-forest planning processes.

The dry-forest restoration guide also states: “The most important goal is to restore Dry Forests, and their associated meadows and seeps, over large areas. If that means slightly modifying your prescription to improve the economic viability of the sale, such modest changes (i.e., within limits as described above) are likely to be worth the ecological cost" (Franklin et al. 2013: 111).

My rationale for removing young grand fir and Douglas-fir (< 150 years) over 21" dbh in dry-forest treatment units, but only when they are located within a 2-dripline distance of a desirable tree, contributes to a common Blue Mountains dry-forest restoration goal: Restore and promote open stands of old forest dominated by ponderosa pine, thereby moving the area toward its historical range of variation for structure, density, and species composition.

Amending eastside Forest Plans to set aside a 'hard diameter limit' (21" dbh), as recommended above in a passage from Franklin et al. (2013), could perhaps contribute to ecological resilience and socioeconomic integrity objectives for dry forests (Hessburg et al. 2020).

A dry-forest restoration guide also states, in its Apply Marking Guidelines section: "Retention of all older trees: in addition to retaining older trees we recommend removing fuels and competing vegetation from an area around the trees extending out about 2X the dripline of the old tree canopies; highly desirable structures within the dripline, such as an outstanding younger pine, can be marked for retention" (Franklin et al. 2013: 120).

Other references to using a fuels and competing vegetation distance of twice the dripline distance are also found in the dry-forest restoration guide (see page 139 in Franklin et al. 2013; other '2X' dripline references also exist in that source).

In accordance with the dry-forest guide's marking guidance that a 'desirable structure' may consist of "an outstanding younger pine," younger pines should often be retained within a 2-dripline distance of old desirable trees (depending on circumstances), and not removed as fuels or competing vegetation (Franklin et al. 2013: 120).

When might young grand fir and Douglas-fir (< 150 years abh) over 21" dbh be removed from within a 2-dripline distance of a tree < 21" dbh?

A common circumstance for this outcome is when a smaller tree is old (≥ 150 years abh). But, judgment should be used when 'spacing off' old trees less than 21" dbh – old trees < 10" dbh seldom develop bark, crown, branching, and other morphological characteristics allowing their age to be accurately estimated by using Van Pelt's (2008) tree-age guide.

Therefore, I suggest that young grand fir and Douglas-fir (< 150 years abh) and over 21" dbh should only be removed from within a 2-dripline distance of old (≥ 150 years abh) trees that are greater than 10" dbh; note that for typical dry-forest conditions, smaller old trees are often greater than or equal to 16" dbh.

Using an Age Threshold to Identify Old Trees

Forest Service managers are attempting to move away from diameter-based criteria and toward more use of age-based standards. An example is provided by a draft "Blue Mountains National Forests Proposed Revised Land Management Plan" (USDA Forest Service 2014), which provides a desired condition (DC) statement in section 2.2.2 pertaining to identification of old trees (in contrast to identification of old stands) (USDA Forest Service 2014, p. 53):

2.2.2 Individual Old Trees
Desired Condition: Individual live old trees are maintained both within and outside of old forest stands to meet a wide variety of ecological and social values. For most tree species, certain physical tree characteristics can be used to infer old age. Old age for most tree species is generally considered to be greater than 150 years in age. However, old tree characteristics and old age may vary by species and site. A description of these characteristics and age should be further developed on a site-specific project basis.

Unlike the Eastside Screens, this desired condition statement from a proposed revised Forest Plan uses age ("greater than 150 years in age") instead of diameter to define old trees.

Dry forest projects proposed for Blue Mountains national forests could choose to do the same by amending the Eastside Screens portion of their existing Forest Plan to use an age of 150 years abh for defining late-old structure (in lieu of the Screens' 21-inch diameter limit).

An important reason for using age as a criterion for identifying old trees is that diameter has been shown to be a poor (or at least an inconsistent) proxy for tree age (Van Pelt 2008), both at a broad scale and at the project scale (fig. 61). A 21-inch diameter limit can effectively identify large structure, but as described here, we should not assume that a 21" tree diameter is an effective surrogate for Eastside Screens 'late and old structure.'

Diameter limits (including a 21" dbh standard used by Eastside Screens) are viewed as an operationally desirable measure – tree diameter is objectively and quickly determined in the field by measuring it with a steel diameter tape. Obtaining an objective estimate of tree age, however, involves coring a tree with an increment borer, and this requires substantially more time and effort than measuring tree diameter.

Another reason for moving away from a 21" diameter limit is that it does not prohibit removal of small, but old, trees. Recent science suggests that old trees are an important ecosystem component (Franklin et al. 2008, 2013; Van Pelt 2008), and their ecological value tends not to be size-specific – a 16" dbh tree that is 150 years old has just as much 'value' as a 22" dbh tree that is 150 years old, but the Eastside Screens generally require that a 22" dbh tree be retained, and yet they do not prohibit removal of an old, 16" dbh tree.

Regardless of desires related to objectivity or operational simplicity, more than a quarter-century of experience with an Eastside Screens 21" diameter limit has clearly shown that tree size is generally a poor surrogate for tree age (Van Pelt 2008) (fig. 61), so:

A 21" dbh standard can effectively identify *large trees* (if 21" is defined as 'large'), but

A 21" dbh standard cannot accurately identify old trees.

Some stakeholders and collaborative groups recognize the logic of using age, rather than diameter, as a metric to identify mature and old trees. This sentiment is expressed well in a quoted passage describing recent collaboration for Soda Bear project in Grant County, Oregon, where 20,000 acres of forest restoration treatments were proposed in a planning area comprised primarily of dry upland forests.

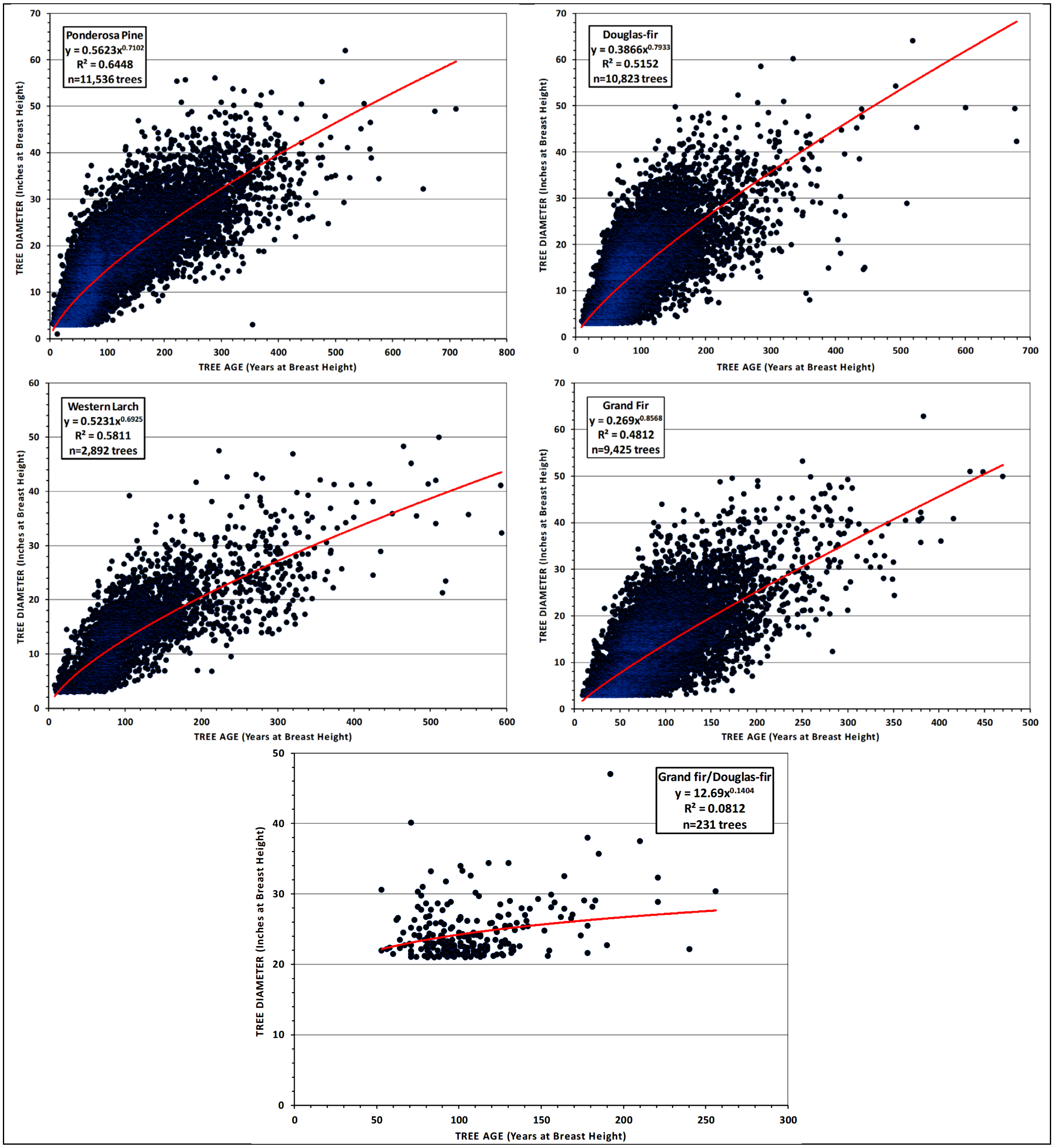

Figure 61 – Age-diameter regressions for Blue Mountains tree species. A regression utilizing tree records with measured age and dbh values from Current Vegetation Survey plots for the Blue Mountains (42,464 total records) was completed for each species. Species included here are common on dry-forest sites – ponderosa pine, Douglas-fir, western larch, and grand fir (top four images). Bottom image shows a regression based on 231 cored trees from unit 57a in Kahler planning area on Heppner Ranger District, Umatilla National Forest (mix of grand fir and Douglas-fir only; all cored trees were ≥ 21" dbh. Fig. 62 provides additional information about Kahler unit 57a).

Collaboration for Soda Bear project involved Blue Mountains Forest Partners (a collaborative group headquartered in John Day, Oregon), USDA Forest Service (Malheur National Forest), and two university professors from University of Washington and Oregon State University (Brown 2012). Here is what was said about Soda Bear collaboration and its results:

"Of particular importance to the BMFP [Blue Mountains Forest Partners] was the treatment and retention of mature and old-growth tree species: on the Malheur National Forest, harvest rules prohibit the removal of living trees 21 inches in diameter at breast height (dbh) or greater. This requirement restricts the removal of young, but large, tree species such as grand fir (*Abies grandis*), and did not prohibit the removal of small, but old, trees. Predictably, this rule also reduced the amount of timber volume that could be harvested in an ecologically sensitive way, a significant issue in the economically depressed community.

In an attempt to address these rule-based shortcomings, Franklin and Johnson [see Franklin and Johnson 2012] recommended adapting a set of guidelines designed to distinguish old from large trees. This guide (Van Pelt 2008) uses environmental conditions and external characteristics to estimate tree age classes. Throughout this process, the BMFP supported the multitiered approach of Franklin and Johnson, and was particularly interested in how the new age-sensitive marking guidelines would have the desired outcome of protecting mature and old-growth pine, Douglas-fir (*Pseudotsuga menziesii*), and western larch (*Larix occidentalis*), while allowing the harvest of large, young grand fir or would simply constrain management further" (Brown 2012).

Information presented in figure 61 was derived from Current Vegetation Survey (CVS) plots distributed across all three of the Blue Mountains national forests. More than two thousand CVS plots exist, in total, across the three national forests; only those CVS plots supporting forest ecosystems were used for the analysis.

Tree records from occasion 1 surveys completed generally between 1993 and 1996 are reflected in figure 61. After extracting tree records with measured values of diameter and age (42,464 records involving 13 tree species), records for the four most common species occurring on dry-forest sites were used for a regression (trend-line) analysis in the Excel® spreadsheet application (the four species are ponderosa pine, Douglas-fir, grand fir, and western larch).

In trend-line analyses, an independent (x-axis) variable is tree diameter; a dependent (y-axis) variable is tree age. Data points consisting of tree diameter and tree age measurements, as stratified by tree species, were plotted as a scatter (X-Y) chart.

Excel provides at least half a dozen trend-line alternatives; a variety of options were examined, and one option (power function, a nonlinear alternative) was selected for all species because it tended to produce the highest coefficient of determination (R^2) value.

[Note that a power function did not necessarily produce the highest value for every species, but overall it provided the best fit so it was used for all species in the interest of consistency.]

Results from regression (trend-line) analyses are presented in a box in the upper left corner for each species included in figure 61 – information in the box includes a species name, an equation relating tree age (y) to tree diameter (x), a coefficient of determination (R^2) value, and the number of tree records used for a regression (n value).

R^2 values in figure 61 are always positive, indicating that a positive statistical association exists between an independent variable (tree diameter) and a dependent variable (tree age).

A relationship between tree diameter and age, however, is not a cause-and-effect relationship – it likely reflects a mutual interaction between these two variables. Rather than tree diameter **causing** variation in tree age, it is more reasonable to think of these two attributes as varying in tandem, and not reflecting a one-way causal relationship (Kent and Coker 2002).

Trend-line analyses presented in figure 61 have these results:

- Ponderosa pine: R^2 value of 0.6448 for 11,536 measured trees from 1 to 62.0" dbh.
- Douglas-fir: R^2 value of 0.5152 for 10,823 measured trees ranging from 3 to 64.1" dbh.
- Western larch: R^2 value of 0.5811 for 2,892 measured trees ranging from 3 to 50.0" dbh.
- Grand fir: R^2 value of 0.4812 for 9,425 measured trees ranging from 3 to 62.9" dbh.

Note: When comparing two variables, an R^2 value is used to estimate how much variation in a dependent variable can be attributed to an independent variable. For ponderosa pine, for example, 64.48% of variation in tree age is related to tree diameter. The remainder of tree-age variation (35.52%) is apparently related to factors other than tree diameter.

Recent science-based recommendations (Franklin and Johnson 2012; Franklin et al. 2008, 2013; Hessburg and Agee 2003; and many others) emphasize retention of trees greater than 150 years of age because these trees established before extensive Euro-American settlement and associated changes caused by fire exclusion, livestock grazing, selective timber harvest, and climate change.

In addition, it is commonly observed that dry-forest trees begin exhibiting many structural and functional characteristics of 'old growth' by 150 years (Franklin and Johnson 2012, Franklin et al. 2008, Van Pelt 2008).

Is Science Associated With 1990 Blue Mountains Plans Current?

Science citations in previous paragraphs are generally more recent than 1990, when Blue Mountains Forest Plans were approved (USDA Forest Service 1990); citations are also more current than the Eastside Screens, approved in 1994 and 1995 (USDA Forest Service 1994, 1995).

This situation suggests that Blue Mountains national forests Forest Plans, approved decades ago and based largely on science developed from late 1970s to late 1980s, are considered obsolete by some stakeholders (Brown 2012) and agency employees. Forest science evolves through time, and rationale for approaches described in this appendix is based mostly on more recent science than was used for 1990 Forest Plans and an Eastside Screens amendment.

How should trees greater than 150 years of age be identified for dry-forest ecosystems? A relatively recent field guide (Van Pelt 2008) uses morphological characteristics (e.g., bark condition, knot indicators, crown form, etc.) to provide an approximate age for ponderosa pine, Douglas-fir, and western larch growing in eastern Washington. The Van Pelt (2008) guide does not include an age-evaluation protocol for grand fir, another common dry-forest tree species.

Geographical context for a Van Pelt (2008) guide is eastern Washington. Umatilla National Forest contains lands in eastern Washington (entire Pomeroy Ranger District, and portion of

Walla Walla Ranger District), but other Blue Mountains national forests only include lands in eastern Oregon or west-central Idaho.

My experience is that vegetation and ecological conditions in southeastern Washington are equivalent to those in northeastern Oregon. A recent assessment of Umatilla National Forest resource conditions corroborates my experience and assertion (Christensen et al. 2007).

Therefore, an old-tree identification field guide developed for eastern Washington (Van Pelt 2008) is considered appropriate for use in adjoining areas of eastern Oregon.

When applying Van Pelt's (2008) field guide, users make visual estimates for three or more categories of tree characteristics, such as lower trunk bark fissures (MacFarlane and Luo 2009), knot indicators on main trunk below crown, and crown form. Each tree species included in Van Pelt 2008 has a slightly different number and type of categories.

Rating scores, by individual category, are combined by using a decision key to derive an overall score for a sample tree. A Scoring Key, specific to each tree species, is then used to identify an approximate age range for a tree.

This process is compatible with a need to identify trees whose age is greater than or equal to 150 years because the Scoring Key for all three applicable tree species – ponderosa pine, western larch, Douglas-fir – have an age-class break occurring at 150 years. If this was not true, then a Van Pelt (2008) guide may not be suitable for identifying trees ≥ 150 years.

Although a Van Pelt (2008) guide does include an individual species treatment for grand fir (see pages 133-144 in Van Pelt 2008), it does not provide a key with individual categories of morphological characteristics, or an overall Scoring Key, to derive a final age estimate.

Therefore, any grand fir trees whose diameter exceeds 21" dbh, but for which there is uncertainty about whether their age exceeds 150 years, would need to be cored with an increment borer to derive an estimated age at breast height.

Age limits have been criticized as being more difficult to apply than diameter limits (Franklin and Johnson 2012), primarily because age criteria typically require each tree to be cored with an increment borer. Recent experience with Van Pelt's (2008) guide for preliminary marking of treatment units for a Blue Mountains dry-forest project (Kahler) suggests it works well.

This accuracy assessment is based on extensive tree coring to compare Van Pelt (2008) age estimates with actual age measurements. A coring validation exercise involved four tree species in one large treatment unit in the Kahler project (fig. 62; also see bottom image in fig. 61).

[Even though Van Pelt (2008) does not provide a grand fir Scoring Key, grand fir trees were cored during field validation efforts because this approach provides an overall sense of how many large grand firs are also young.]

Field validation (fig. 62) indicates that a Van Pelt (2008) guide acceptably identifies trees whose breast-height age is 150 years or greater, but it is still important that "stakeholders and agency personnel must agree on some allowance for errors in age estimation" for this process to work in an operational (timber marking) setting (Franklin and Johnson 2012, p. 437).

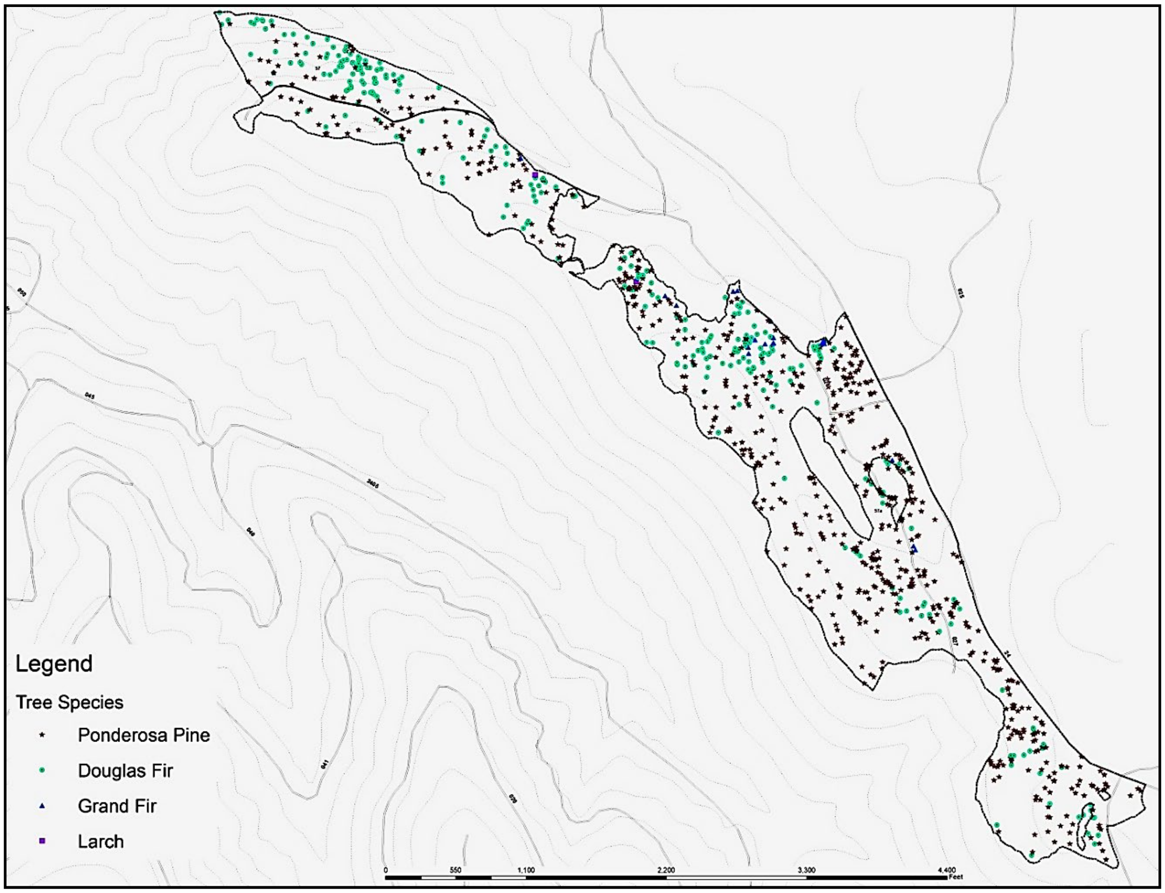

Figure 62 – Trees cored in Kahler unit 57a to determine tree age, at breast height, as a validation exercise for applying a Van Pelt (2008) old-tree identification guide. This map shows location of 266 Douglas-firs, 19 grand firs, 2 western larches, and 650 ponderosa pines that were cored to determine breast-height age during a validation exercise related to a Van Pelt (2008) old-tree field guide. Some trees shown here were included in a regression exercise to examine a relationship between dbh and tree age for a mix of grand firs and Douglas-firs in unit 57a (see bottom image in fig. 61).

As discussed in this appendix, an approach for reducing representation of large (≥ 21" dbh) and young (< 150 years) Douglas-firs and grand firs on dry-forest sites in the Blue Mountains could incorporate the following specifications:

1. <u>Definitions</u>: Old trees are those whose age, at breast height (same point on tree where diameter is measured), is ≥ 150 years. Young trees are those whose breast-height age is < 150 years.
2. For all tree species except Douglas-fir and grand fir, trees ≥ 21" dbh should be retained regardless of their age, especially when required by scenario A of Eastside Screens amendment to 1990 Blue Mountains Forest Plans, unless these trees qualify as a danger tree or pose an imminent safety hazard (Toupin et al. 2008).
3. During operational marking of treatment units, a Van Pelt (2008) guide should be used, in conjunction with ocular evaluation of external tree characteristics, to estimate age for ponderosa pine, western larch, and Douglas-fir trees (regardless of diameter) whose morphological traits, as related to bark, crown, and branching characteristics, suggest they may be old.

4. Old ponderosa pines, Douglas-firs, and western larches will be retained, unless their size is less than 10" dbh. [Old trees < 10" dbh tend to be long suppressed, and they seldom develop bark, crown, branching, and other morphological traits allowing them to be effectively rated by using Van Pelt's (2008) guide.]
5. If appropriate, a site-specific Forest Plan amendment should be proposed to authorize Douglas-fir and grand fir trees <150 years abh and ≥ 21" dbh to be removed, and tree removal should be guided by the following specifications:
    a. A Scoring Key in Van Pelt (2008) will be used to identify Douglas-fir trees that are large (≥ 21" dbh) but young (< 150 years abh).
    b. A Van Pelt (2008) guide does not provide a Scoring Key for estimating grand fir tree age, so grand firs ≥ 21" dbh and appearing to be young will be cored with an increment borer to determine if their age is < 150 years abh.
    c. Young but large (< 150 years abh, and ≥ 21" dbh) Douglas-fir and grand fir trees will be removed only when they are located within a 2-dripline distance of a desirable tree. As recommended by a Franklin et al. (2013) dry-forest management guide, fuels and competing vegetation should be removed from within a 2-dripline zone surrounding desirable trees. However, outstanding younger trees (such as a thrifty 16" dbh ponderosa pine, for example) can be retained within a 2-dripline zone when their retention does not represent an undue level of intertree competition.
    d. Wildlife considerations should be incorporated in silvicultural prescriptions and marking guides to specify when some young but large (< 150 years abh, and ≥ 21" dbh) Douglas-fir and grand fir trees will be retained for wildlife purposes.

Defining and Determining Dripline Distance

Specifications regarding removal of some large but young Douglas-firs and grand firs are provided in the preceding section. Specifically, they instruct that large but young Douglas-firs and grand firs should be considered for removal only *when they occur within a 2-dripline distance of a desirable tree*.

This means that a decision to remove a large but young Douglas-fir or grand fir would be informed by the following decision hierarchy:

1) Is a large but young Douglas-fir or grand fir in <u>relatively close proximity</u> to another tree (i.e., close enough, in general terms, to evaluate by using detailed distance criteria)?
2) If yes, is the other tree a <u>desirable tree</u>?
3) If yes, is the large but young Douglas-fir or grand fir <u>within a 2-dripline distance</u> of a desirable tree?
4) If yes, does a large but young Douglas-fir or grand fir <u>meet wildlife criteria</u> for removal?

Remainder of this appendix section addresses these questions by: (1) describing desirable trees for a dry-forest context; (2) establishing a definition for 'dripline'; (3) describing the source of a '2-dripline' intertree distance specification; (4) providing a discussion about the rationale for using a dripline-based zone around desirable trees, and whether a 2-dripline distance is appropriate for dry-forest ecosystems; and (5) explaining how a 2-dripline distance specification could be implemented for dry-forest treatments involving timber harvest.

Earlier in this appendix, a desirable tree is defined for a dry-forest context, and the definition includes a tree species hierarchy (preference). See section entitled *Defining Desirable Trees for a Dry-Forest Context*. A species preference list, along with other aspects of defining a desirable tree, is provided on pages 134-35. A tree-species preference list reflects life-history traits (table 13) including seral status; insect, disease, drought, and fire resistance; and similar factors, and it reflects these factors in a context of prevailing Blue Mountains dry-forest conditions.

Primary logic behind removing large *but young* Douglas-firs and grand firs is that old trees – those greater than 150 years abh – are ecologically desirable and valuable, and this is why old trees are listed first in the preference list on page 134. Large but young trees (those less than 150 years abh) growing in close proximity to old trees compete vigorously with them for soil moisture and nutrients. And if large but young trees were not good competitors (or established on good microsites), they would not be able to reach a large diameter in less than 150 years.

One objective of removing large but young Douglas-firs and grand firs is to help prevent development of what are termed 'focus trees,' which function as mountain pine beetle or western pine beetle attractant (Eckberg et al. 1994). It is believed that an otherwise normal tree becomes a focus tree by emitting high levels of volatile chemical compounds (Eckberg et al. 1994, Person 1931), such as ethanol (Kelsey 2001), and trees produce these chemical compounds in response to stress (Phillips and Croteau 1999).

Bark beetles respond to chemical cues emitted by stressed trees and attack them, often causing tree mortality. Although low levels of 'background' tree mortality are both expected and desirable (functioning as a source of snags, for example), high levels of beetle-caused tree mortality on dry-forest sites is undesirable, particularly when the trees being killed are old ponderosa pines occurring at reduced levels when compared with their historical abundance.

An important source of tree stress for old ponderosa pines, and an important contributor to development of focus trees and associated tree mortality from bark-beetle attack, is presence of large but young Douglas-fir or grand fir trees in relatively close proximity to old pines.

A method to characterize the competitive environment between trees growing in close proximity is called **dripline distance**. The dripline concept is illustrated in figure 63. In my judgment, based on more than 30 years of professional experience working with Blue Mountains forest ecosystems as a USDA Forest Service silviculturist, a dripline-distance concept can be used to effectively account for intertree competition relationships for dry-forest sites.

A primary reason that dripline distance can effectively reflect intertree competition is that dry-forest sites are water-limited, and crowns of mature trees growing in water-limited forests do not generally touch crowns of neighboring mature trees.

Root extent better reflects site occupancy for water-limited sites than crown extent (fig. 64); there can be wide distances between adjoining tree crowns on dry sites, and yet trees are fully utilizing the site because soil between trees is completely occupied by tree roots.
[For light or energy-limited settings like Douglas-fir and western hemlock forests of western Oregon, proximity of tree crowns can function as an effective indicator of intertree competition, and dripline distance may have less utility as a proxy for intertree competition on those sites.]

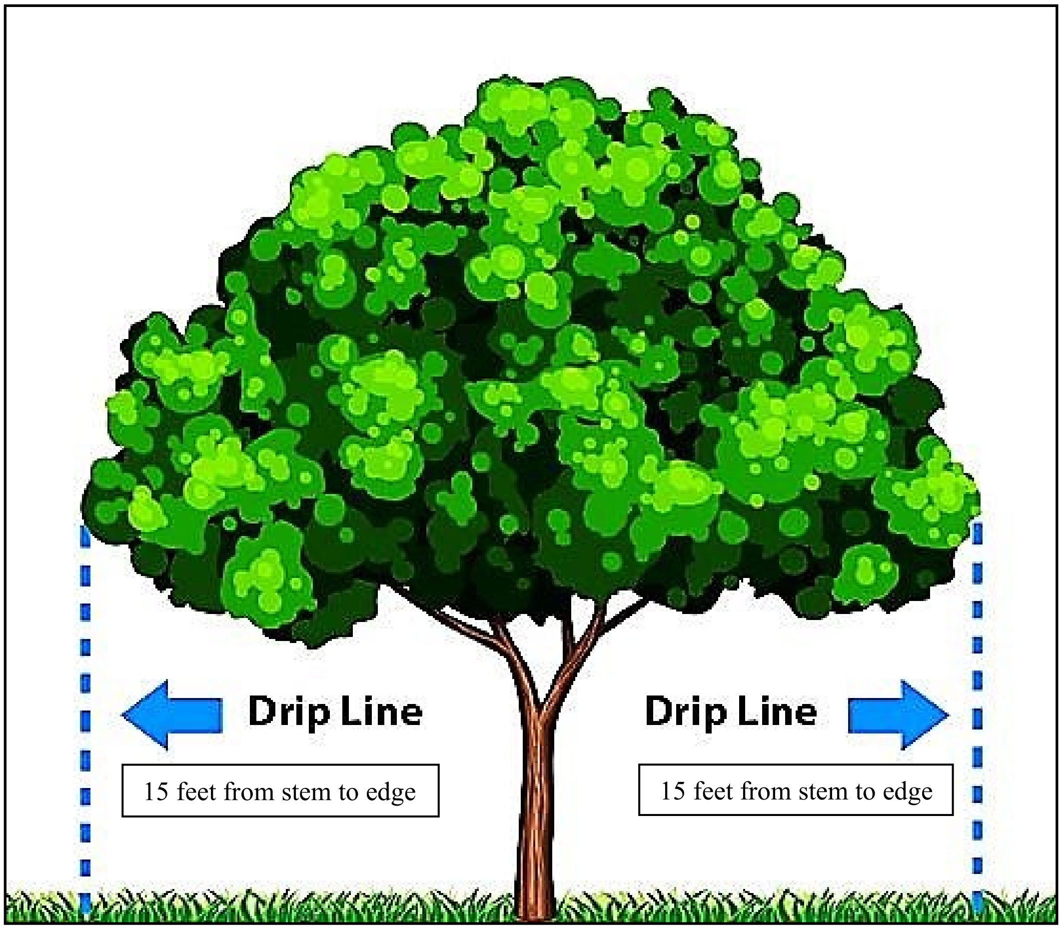

Figure 63 – Diagram illustrating a dripline concept. Dripline is assumed to represent a radial distance, extending from a tree stem (outer edge of stem, not its center) to outermost extent of a tree crown. Some large but young Douglas-firs and grand firs occurring within a 2-dripline distance of a desirable tree should be considered for removal to address concerns related to inter-tree competition, bark-beetle risk, loss of ponderosa pine cover type, and ladder-fuel reduction.

An example – let's say that total crown width (diameter) of this tree is 30 feet, and that its crown shape is symmetrical with the stem exactly in the center. This means that dripline distance is 15 feet (half the crown diameter). To implement a 2-dripline specification for this tree, a radial distance of 30 feet (two driplines) would be measured outward from the stem in any direction.

This process results in the inner half of a 2-dripline zone (first 15 feet from the stem) being underneath the tree's existing crown; the outer half of this 2-dripline zone extends 15 feet beyond the crown and into an area occupied by tree roots. For dry-forest sites, large but young Douglas-firs or grand firs located anywhere in this 30-foot zone (15 feet from stem to outer crown edge, plus 15 feet beyond crown edge) should be evaluated for removal or retention.

As a tree gets larger, its crown gets wider in diameter, and its roots spread wider to keep up with an expanding crown. It has been found that dripline distance can effectively be used to approximate how much of the area around a tree is occupied by its roots.

Large trees have large crowns, so a dripline distance 'multiple' around a large tree is greater than it is for a small tree. Therefore, a 2-dripline distance around a large tree is greater than a 2-dripline distance around a small tree, and this difference is physiologically appropriate because research shows that roots extend farther around a large tree than they do around a small tree.

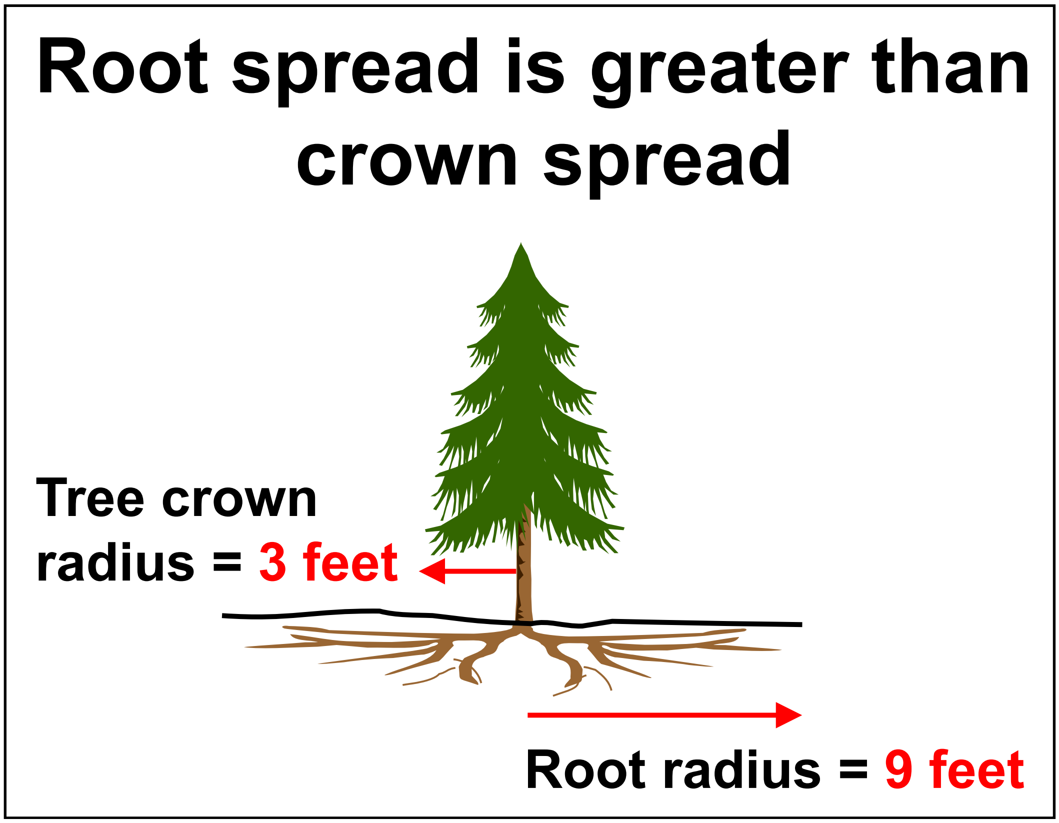

Figure 64 – Diagram illustrating crown spread versus root spread relationships. For conifer species on dry-forest sites, root spread is always greater than crown spread. According to root-spread research studies cited throughout this appendix, root spread is 1.2 to 5.4 times as wide as crown spread for ponderosa pine, 1.4 to 3.0 times as wide for Douglas-fir, and 2.5 to 3.2 times as wide for lodgepole pine. [For example shown here, dripline multiplier is 3 – crown radius (3 feet) times 3 equals root radius (9 feet).]

[Background: As a tree crown expands in size, its leaf area increases. More leaf area represents greater transpirational demand. Increasing amounts of transpiring foliage (more leaf area) requires additional water and nutrients. Increased demand for water and nutrients results in a larger root system because roots are a tree's collection system for water and nutrients.]

Why is a 2-dripline distance recommended for dry-forest sites? The Franklin et al. field guide (Franklin et al. 2013) recommends a 2-dripline distance in two places:

1. An 'Apply Marking Guidelines' section on page 120 states: "Retention of all older trees: in addition to retaining older trees we recommend removing fuels and competing vegetation from an area around the trees extending out about 2x the dripline of the old tree canopies; highly desirable structures within the dripline, such as an outstanding younger pine, can be marked for retention."
2. An 'Example Marking Guide Using the ICO Method' section on page 149 states: "Around old ponderosa pine, remove young trees for 2 driplines – OK to keep 1-2 large/vigorous trees occasionally."

How does the Franklin et al. (2013) guide define dripline – is it radial distance from a tree stem to outermost extent of a tree crown, or is it distance from one edge of a crown to the opposite edge (a crown's diameter)? And why does the Franklin et al. (2013) guide recommend a 2-dripline distance instead of a 1-dripline, 3-dripline, or 5-dripline distance? Unfortunately, careful perusal of the Dry Forest Restoration Guide (Franklin et al. 2013) provides no answers for these questions.

For dry-forest sites in the Blue Mountains, I consider a 2-dripline distance to be conservative. Because pine roots have a lateral distance of up to 5 times the radius of the crown (Berndt and Gibbons 1958, Curtis 1964, Greb and Black 1961, Hermann and Peterson 1969), a standard based on two driplines does not fully account for the fact that as dry-forest sites become hotter and dryer, distance between mature trees must increase to provide sufficient soil moisture and nutrients to ensure their survival and vigor.

Mature ponderosa pines are a dominant and enduring biotic component for dry-forest sites; immature seedlings and saplings are not necessarily persistent, and they certainly do not require as much intertree spacing as mature trees. Rather than emphasizing resilience of seedling- and sapling-sized trees, dry-forest restoration projects focus primarily on improving persistence of an uncommon and much-reduced ecosystem component – mature (old) trees, particularly old ponderosa pines.

In my professional judgment, an intertree distance representing 2 or 3 driplines would be appropriate for Blue Mountains sites assigned to a Warm Dry plant association group. But for drier portions of a Dry Upland Forest PVG, including sites assigned to a Hot Dry plant association group (Powell et al. 2007), an intertree distance representing 3 to 5 driplines is physiologically appropriate.

These dripline recommendations are based on reviewing a relatively wide cross-section of research studies examining root competition and crown spacing relationships for forest ecosystems (Aaltonen 1926, Bright 1914, Coomes and Grubb 2000, Fisher and Gosz 1986, McCune 1986, Pearson 1930, Stuart et al. 1989, Toumey 1926, Zon 1907).

Summary

For dry forests of the Blue Mountains, Forest Plan amendment proposals authorizing removal of young but large Douglas-fir and grand fir trees could be formulated to include candidate trees occurring within a 2-dripline distance of a desirable tree, as recommended by a *Restoration of Dry Forests in Eastern Oregon* field guide (Franklin et al. 2013).

A site-specific Forest Plan amendment to authorize removing large but young grand firs and Douglas-firs (trees ≥ 21" dbh and < 150 years abh) is ecologically well-aligned with species composition, stand density, insect susceptibility, climate change adaptation, and ladder fuel objectives established for dry-forest restoration goals (desired conditions). Discussion relating to these dry-forest restoration goals and objectives is provided throughout this white paper.

Pacific Northwest Region's Regional Forester encouraged national forest line officers "to consider site-specific Forest Plan amendments where this will better meet LOS objectives"

(Goodman 2003, p. 1). Proposals discussed in this appendix are fully compatible with her 'encouragement' to consider site-specific FP amendments for silvicultural activities that better achieve LOS objectives.

Thinning and prescribed fire treatments are well suited to meeting dry-forest LOS goals, including restoration of a large-tree component featuring predominantly ponderosa pine instead of large but young Douglas-fir and grand fir trees.

Experience over a few previous decades has often demonstrated that silvicultural treatments promoting dry-forest LOS conditions do not produce resilient and sustainable outcomes unless some large but young Douglas-firs and grand firs are removed or killed (girdled).

Designing treatments to enhance a ponderosa pine large-tree component is well aligned with Eastside Screens direction to maintain "remnant late and old seral and/or structural live trees greater than or equal to 21 inches in diameter."

The Screens don't define what constitutes 'remnant' for a dry-forest context, but Screens interpretation letters have consistently assumed that 'remnant' refers to a presettlement composition and structure. For dry forests, an ecologically appropriate definition of 'remnant' would encompass ecosystem conditions resulting from frequent, low-severity wildfire, including an open stand density dominated by large-diameter (and old) ponderosa pines.

Discussion in this appendix is fully compatible with an Eastside Screens objective to "maintain open, park-like stand conditions where this condition occurred historically" (USDA Forest Service 1995). A key first step toward restoring an open, parklike condition is to reduce representation of Douglas-firs and grand firs on dry-forest sites. A carefully designed regime of maintenance actions (thinning and prescribed fire) could then ensure that an open, parklike condition is perpetuated into the future, providing both ecosystem and climate resilience.

In response to Regional Forester Goodman's letter (Goodman 2003), Umatilla National Forest's Forest Supervisor also encouraged employees to consider removal of large trees of undesirable species or condition under certain circumstances (Blackwood 2003, p. 4):

"Large trees with insect or disease issues limiting their capability to contribute to an area's desired future condition, or late-seral species occurring in proportions exceeding HRV with respect to species composition, are two examples of situations where minor numbers of large trees may be designated for removal within the context of an overall thinning prescription."

"If incidental removal of large trees occurs, however, it is assumed that the post-treatment stand will contain a large-tree component sufficient to qualify it as LOS (in other words, the stand was LOS before treatment and it is still LOS after treatment), *and that a site-specific Forest Plan amendment will be processed to disclose that some portion of the large trees are proposed for removal, and to develop the rationale for their removal*."

In my judgment, discussion and rationale presented in this appendix are fully compatible with USDA Forest Service policy and guidance from Pacific Northwest Regional Forester Goodman (Goodman 2003) and Umatilla National Forest Supervisor Blackwood (Blackwood 2003).

DRY-FOREST REFERENCES AND LITERATURE CITED

This section includes literature cited in text, along with other references having relevance to ecology and management of dry forests in the Blue Mountains of northeastern Oregon, southeastern Washington, and west-central Idaho.

Cautionary note about dry-forest references: users of literature in this section should consider that concerns about dry forest exist for all of western North America, so research involving dry-forest ecosystems spans a broad geographical area ranging from southern Okanagan Valley of British Columbia to Black Hills of South Dakota, Colorado's Front Range, Mogollon Rim in Arizona, and Sierra Nevada Mountains of California.

I believe it is useful for practitioners to be aware of a wide breadth of dry-forest research, and I have attempted to provide a relatively diverse array of sources in this section.

It is also important to recognize that dry-forest studies pertaining to Blue Mountains and adjacent portions of interior Pacific Northwest qualify as primary, place-based research, findings from northern Rockies (particularly for areas located west of Continental Divide) qualify as valuable secondary sources, and works from the Southwest or Sierra Nevada are tertiary sources.

Note: I believe Sierra Nevada research is more appropriate for summer-dry Mediterranean climates of the Blue Mountains than sources derived from monsoon climates of the Southwestern U.S. or the southern Front Range of Colorado.

This cautionary note is particularly germane to literature describing dry-forest reference conditions. Excellent insights about historical conditions for ponderosa pine ecosystems of the southwestern U.S. are provided by Gus Pearson (1923), Gil Schubert (1974), Charles Avery (Avery et al. 1976), Charles Cooper (1960, 1961a), and others, but in my opinion, their characterizations of presettlement stand structure (stocking levels, etc.) should not be extrapolated to dry-forest ecosystems of eastern Oregon, *or extrapolation should be attempted very carefully*, due to climatic and environmental differences between these two regions.

Literature and References Availability

My goal with this white paper is not just to include dry-forest literature – I want to make it as easy as possible for managers to access the items in this section. With few exceptions, all sources provided below are available from World Wide Web in digital form, and a Digital Object Identifier (doi) is included for these items whenever possible.

[Digital object identifier is an international system used to uniquely identify, and link to, electronic versions of scientific information, primarily journal articles. A doi can be thought of as a 'catalog number' for journal articles and other non-book sources.]

All doi links pertain to formally published sources only; local analysis protocols, white papers (like this one), monitoring reports, and similar items do not have a doi. Books and longer items have an International Standard Book Number (isbn), and they are included here as well.

For recent USDA Forest Service research reports (general technical reports, research papers, research notes, conference proceedings, etc.), a doi may also be available. But most reports do not yet have a doi, so a doi is not included for reports in this References section.

For FS research items, however, this section provides a weblink for the online Treesearch system, because most FS research reports are available for download from Treesearch.

Because one of my objectives is to help users locate these references and literature citations, I provide a doi or isbn number whenever one is available. For other reference materials, a weblink is provided, although I realize that unfortunately, weblinks are not stable (except for USDA Forest Service Treesearch links, which have been quite stable thus far).

Aaltonen, V.T. 1926. On the space arrangement of trees and root competition. Journal of Forestry. 24(6): 627-644. doi:10.1093/jof/24.6.627

Abatzoglou, J.T.; Williams, A.P. 2016. Impact of anthropogenic climate change on wildfire across western US forests. Proceedings of the National Academy of Sciences. 113(42): 11770-11775. doi:10.1073/pnas.1607171113

Abella, S.R. 2004. Tree thinning and prescribed burning effects on ground flora in Arizona ponderosa pine forests: A review. Journal of the Arizona-Nevada Academy of Science. 36(2): 68-76. https://www.jstor.org/stable/27641698

Abella, S.R.; Covington, W.W. 2006. Forest ecosystems of an Arizona Pinus ponderosa landscape: Multifactor classification and implications for ecological restoration. Journal of Biogeography. 33(8): 1368-1383. doi:10.1111/j.1365-2699.2006.01513.x

Abella, S.R.; Denton, C.W. 2009. Spatial variation in reference conditions: Historical tree density and pattern on a *Pinus ponderosa* landscape. Canadian Journal of Forest Research. 39(12): 2391-2403. doi:10.1139/X09-146

Abella, S.R.; Fulé, P.Z.; Covington, W.W. 2006. Diameter caps for thinning southwestern ponderosa pine forests: Viewpoints, effects, and tradeoffs. Journal of Forestry. 104(8): 407-414. doi:10.1093/jof/104.8.407

Abella, S.R.; Covington, W.W.; Fulé, P.Z.; Lentile, L.B.; Sánchez Meador, A.J.; Morgan, P. 2007a. Past, present, and future old growth in frequent-fire conifer forests of the western United States. Ecology and Society. 12(2): art16 [16 p]. http://www.ecologyandsociety.org/vol12/iss2/art16/

Abella, S.R.; Springer, J.D.; Covington, W.W. 2007b. Seed banks of an Arizona *Pinus ponderosa* landscape: responses to environmental gradients and fire cues. Canadian Journal of Forest Research. 37(3): 552-567. doi:10.1139/X06-255

Abella, S.R.; Denton, C.W.; Steinke, R.W.; Brewer, D.G. 2013. Soil development in vegetation patches of *Pinus ponderosa* forests: Interface with restoration thinning and carbon storage. Forest Ecology and Management. 310: 632-642. doi:10.1016/j.foreco.2013.09.022

Abella, S.R.; Chiquoine, L.P.; Sinanian, P.A. 2015. Forest change over 155 years along biophysical gradients of forest composition, environment, and anthropogenic disturbance. Forest Ecology and Management. 348: 196-207. doi:10.1016/j.foreco.2015.01.033

Abrahamson, W.G. 1984. Fire: Smokey Bear is wrong. BioScience. 34(3): 179-180. doi:10.2307/1309755

Adams, L. 1951. White-tailed deer browsing on ponderosa pine plantations. Research Note No. 89. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 5 p. https://archive.org/download/CAT31015291/CAT31015291.pdf

Adams, D.M.; Latta, G.S. 2005. Costs and regional impacts of restoration thinning programs on the national forests in eastern Oregon. Canadian Journal of Forest Research. 35(6): 1319-1330. doi:10.1139/x05-065

Adams, H.D.; Guardiola-Claramonte, M.; Barron-Gafford, G.A.; Villegas, J.C.; Breshears, D.D.; Zou, C.B.; Troch, P.A.; Huxman, T.E. 2009. Temperature sensitivity of drought-induced tree mortality portends increased regional die-off under global-change-type drought. Proceedings of the National Academy of Sciences. 106(17): 7063-7066. doi:10.1073/pnas.0901438106

Addington, R.N.; Aplet, G.H.; Battaglia, M.A.; Briggs, J.S.; Brown, P.M.; Cheng, A.S.; Dickinson, Y.; Feinstein, J.A.; Pelz, K.A.; Regan, C.M.; Thinnes, J.; Truex, R.; Fornwalt, P.J.; Gannon, B.; Julian, C.W.; Underhill, J.L.; Wolk, B. 2018. Principles and practices for the restoration of ponderosa pine and dry mixed-conifer forests of the Colorado Front Range. Gen. Tech. Rep. RMRS-GTR-373. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 121 p. https://www.fs.usda.gov/treesearch/pubs/55638

Agee, J.K. 1990. The historical role of fire in Pacific Northwest forests. Chapter 3. In: Walstad, J.D.; Radosevich, S.R.; Sandberg, D.V., eds. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press: 25-38. isbn:0-87071-359-0

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 493 p. isbn:1-55963-229-1

Agee, J.K. 1994. Fire and weather disturbances in terrestrial ecosystems of the eastern Cascades. Gen. Tech. Rep. PNW-GTR-320. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 52 p. http://www.treesearch.fs.fed.us/pubs/6225

Agee, J.K. 1996a. Achieving conservation biology objectives with fire in the Pacific Northwest. Weed Technology. 10(2): 417-421. http://www.jstor.org/stable/info/3988077

Agee, J.K. 1996b. Fire in the Blue Mountains: A history, ecology, and research agenda. Chapter 7. In: Jaindl, R.G.; Quigley, T.M., eds. Search for a solution: sustaining the land, people, and economy of the Blue Mountains. Washington, DC: American Forests: 119-145.

Agee, J.K. 1996c. The influence of forest structure on fire behavior. In: Proceedings of the seventeenth annual forest vegetation management conference; 1996 January 16-18; Redding, CA: 52-68. http://www.fvmc.org/PDF/FVMCProc17th(1996).pdf

Agee, J.K. 1997. Restoration of Blue Mountain forests with fire: Is it possible? Natural Resource News. 7(3): 3,6.

Agee, J.K. 1998. The landscape ecology of western forest fire regimes. Northwest Science. 72(Special Issue): 24-34.

Agee, J.K. 2002a. Fire as a coarse filter for snags and logs. In: Laudenslayer, W.F., Jr.; Shea, P.J.; Valentine, B.E.; Weatherspoon, C.P.; Lisle, T.E., eds. Proceedings of the symposium on the ecology and management of dead wood in western forests. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 359-368. http://www.treesearch.fs.fed.us/pubs/6718

Agee, J.K. 2002b. The fallacy of passive management: Managing for firesafe forest reserves. Conservation In Practice. 3(1): 18-25. doi:10.1111/j.1526-4629.2002.tb00023.x

Agee, J.K. 2003. Historical range of variability in eastern Cascade forests, Washington, USA. Landscape Ecology. 18(8): 725-740. doi:10.1023/B:LAND.0000014474.49803.f9

Agee, J.K. 2007. Keynote address: the role of silviculture in restoring fire-adapted ecosystems. In: Powers, R.F., tech. ed. Restoring fire-adapted ecosystems: proceedings of the 2005 national silviculture workshop. Gen. Tech. Rep. PSW-GTR-203. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: ix-xviii. https://www.fs.usda.gov/treesearch/pubs/25887

Agee, J.K.; Lehmkuhl, J.F. 2009. Dry forests of the northeastern Cascades Fire and Fire Surrogate project site, Mission Creek, Okanogan-Wenatchee National Forest. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 158 p. http://www.treesearch.fs.fed.us/pubs/31913

Agee, J.K.; Lolley, M.R. 2006. Thinning and prescribed fire effects on fuels and potential fire behavior in an eastern Cascades forest, Washington, USA. Fire Ecology. 2(2): 142-158. doi:10.4996/fireecology.0202003

Agee, J.K.; Maruoka, K.R. 1994. Historical fire regimes of the Blue Mountains. Tech Note BMNRI-TN-1. La Grande, OR: USDA Forest Service, Blue Mountains Natural Resources Institute. 4 p.

Agee, J.K.; Skinner, C.N. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management. 211(1-2): 83-96. doi:10.1016/j.foreco.2005.01.034

Agee, J.K.; Bahro, B.; Finney, M.A.; Omi, P.N.; Sapsis, D.B.; Skinner, C.N.; van Wagtendonk, J.W.; Weatherspoon, C.P. 2000. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management. 127(1-3): 55-66. doi:10.1016/S0378-1127(99)00116-4

Ager, A.A.; McMahan, A.J.; Barrett, J.J.; McHugh, C.W. 2007a. A simulation study of thinning and fuel treatments on a wildland-urban interface in eastern Oregon, USA. Landscape and Urban Planning. 80(3): 292-300. doi:10.1016/j.landurbplan.2006.10.009

Ager, A.A.; McMahan, A.; Hayes, J.L.; Smith, E.L. 2007b. Modeling the effects of thinning on bark beetle impacts and wildfire potential in the Blue Mountains of eastern Oregon. Landscape and Urban Planning. 80(3): 301-311. doi:10.1016/j.landurbplan.2006.10.010

Ager, A.A.; Vaillant, N.M.; Finney, M.A. 2010. A comparison of landscape fuel treatment strategies to mitigate wildland fire risk in the urban interface and preserve old forest structure. Forest Ecology and Management. 259(8): 1556-1570. doi:10.1016/j.foreco.2010.01.032

Ager, A.A.; Vaillant, N.M.; Finney, M.A.; Preisler, H.K. 2012. Analyzing wildfire exposure and source–sink relationships on a fire prone forest landscape. Forest Ecology and Management. 267: 271-283. doi:10.1016/j.foreco.2011.11.021

Ager, A.A.; Buonopane, M.; Reger, A.; Finney, M.A. 2013. Wildfire exposure analysis on the national forests in the Pacific Northwest, USA. Risk Analysis. 33(6): 1000-1020. doi:10.1111/j.1539-6924.2012.01911.x

Ager, A.A.; A. Day, M.; Finney, M.A.; Vance-Borland, K.; Vaillant, N.M. 2014a. Analyzing the transmission of wildfire exposure on a fire-prone landscape in Oregon, USA. Forest Ecology and Management. 334: 377-390. doi:10.1016/j.foreco.2014.09.017

Ager, A.A.; Day, M.A.; McHugh, C.W.; Short, K.; Gilbertson-Day, J.; Finney, M.A.; Calkin, D.E. 2014b. Wildfire exposure and fuel management on western US national forests. Journal of Environmental Management. 145: 54-70. doi:10.1016/j.jenvman.2014.05.035

Ager, A.A.; Houtman, R.M.; Day, M.A.; Ringo, C.; Palaiologou, P. 2019. Tradeoffs between US national forest harvest targets and fuel management to reduce wildfire transmission to the wildland urban interface. Forest Ecology and Management. 434: 99-109. doi:10.1016/j.foreco.2018.12.003

Ager, A.A.; Barros, A.M.G.; Houtman, R.; Seli, R.; Day, M.A. 2020. Modelling the effect of accelerated forest management on long-term wildfire activity. Ecological Modelling. 421: 108962 (13 p). doi:10.1016/j.ecolmodel.2020.108962

Ahlgren, I.F.; Ahlgren, C.E. 1960. Ecological effects of forest fires. Botanical Review. 26(4): 483-

533. doi:10.2307/4353623

Aldous, A.E. 1914. Memorandum office report of trip on Umatilla Forest, September 15 to 18, inclusive. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 18 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015567.pdf

Alexander, R.R. 1986. Silvicultural systems and cutting methods for ponderosa pine forests in the Front Range of the central Rocky Mountains. Gen. Tech. Rep. RM-128. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 22 p. https://www.fs.usda.gov/treesearch/pubs/37957

Alexander, R.R. 1987. Silvicultural systems, cutting methods, and cultural practices for Black Hills ponderosa pine. Gen. Tech. Rep. RM-139. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 32 p. https://archive.org/download/CAT87882180/CAT87882180.pdf

Alexander, M.E. 1988. Help with making crown fire hazard assessments. In: Fischer, W.C.; Arno, S.F., comps. Protecting people and homes from wildfire in the interior West: Proceedings of the symposium and workshop. Gen. Tech. Rep. INT-251. Ogden, UT: USDA Forest Service, Intermountain Research Station: 147-156. https://archive.org/download/CAT89908995/CAT89908995.pdf

Alexander, R.R.; Edminster, C.B. 1980. Management of ponderosa pine in even-aged stands in the Southwest. Res. Pap. RM-225. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 11 p. https://www.archive.org/download/CAT92273441/CAT92273441.pdf

Alexander, R.R.; Edminster, C.B. 1981. Management of ponderosa pine in even-aged stands in the Black Hills. Res. Pap. RM-228. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 10 p. https://www.archive.org/download/CAT92273444/CAT92273444.pdf

Allen, C.D.; Breshears, D.D. 1998. Drought-induced shift of a forest-woodland ecotone: Rapid landscape response to climate variation. Proceedings of the National Academy of Sciences of the United States of America. 95(25): 14839-14842. doi:10.1073/pnas.95.25.14839

Allen, T.F.H.; Wyleto, E.P. 1983. A hierarchical model for the complexity of plant communities. Journal of Theoretical Biology. 101(4): 529-540. doi:10.1016/0022-5193(83)90014-0

Allen, C.D.; Savage, M.; Falk, D.A.; Suckling, K.F.; Swetnam, T.W.; Schulke, T.; Stacey, P.B.; Morgan, P.; Hoffman, M.; Klingel, J.T. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. Ecological Applications. 12(5): 1418-1433. doi:10.1890/1051-0761(2002)012[1418:EROSPP]2.0.CO;2

Allen, C.D.; Macalady, A.K.; Chenchouni, H.; Bachelet, D.; McDowell, N.; Vennetier, M.; Kitzberger, T.; Rigling, A.; Breshears, D.D.; Hogg, E.H.; Gonzalez, P.; Fensham, R.; Zhang, Z.; Castro, J.; Demidova, N.; Lim, J.-H.; Allard, G.; Running, S.W.; Semerci, A.; Cobb, N. 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management. 259(4): 660-684. doi:10.1016/j.foreco.2009.09.001

Allen, C.D.; Breshears, D.D.; McDowell, N.G. 2015. On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. Ecosphere. 6(8): 129 (55 p). doi:10.1890/ES15-00203.1

Amato, V.J.W.; Lightfoot, D.; Stropki, C.; Pease, M. 2013. Relationships between tree stand density and burn severity as measured by the Composite Burn Index following a ponderosa pine forest wildfire in the American Southwest. Forest Ecology and Management. 302: 71-84. doi:10.1016/j.foreco.2013.03.015

Ames, F. 1931. Selective logging on the national forests of the Douglas fir region. Journal of Forestry. 29(5): 768-774. doi:10.1093/jof/29.5.768

Amman, G.D. 1983. Strategy for reducing mountain pine beetle infestations with ponderosa pine trap logs. Res. Note INT-338. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 4 p. https://archive.org/download/strategyforreduc338amma/strategyforreduc338amma.pdf

Andariese, S.W.; Covington, W.W. 1986. Changes in understory production for three prescribed burns of different ages in ponderosa pine. Forest Ecology and Management. 14(3): 193-203. doi:10.1016/0378-1127(86)90117-9

Anderegg, W.R.L.; Kane, J.M.; Anderegg, L.D.L. 2013. Consequences of widespread tree mortality triggered by drought and temperature stress. Nature Climate Change. 3(1): 30-36. doi:10.1038/nclimate1635

Anderegg, W.R.L.; Hicke, J.A.; Fisher, R.A.; Allen, C.D.; Aukema, J.; Bentz, B.; Hood, S.; Lichstein, J.W.; Macalady, A.K.; McDowell, N.; Pan, Y.; Raffa, K.; Sala, A.; Shaw, J.D.; Stephenson, N.L.; Tague, C.; Zeppel, M. 2015. Tree mortality from drought, insects, and their interactions in a changing climate. New Phytologist. 208(3): 674-683. doi:10.1111/nph.13477

Andersen, C.P.; Phillips, D.L.; Rygiewicz, P.T.; Storm, M.J. 2008. Fine root growth and mortality in different-aged ponderosa pine stands. Canadian Journal of Forest Research. 38(7): 1797-1806. doi:10.1139/X08-029

Anderson, L.; Carlson, C.E.; Wakimoto, R.H. 1987. Forest fire frequency and western spruce budworm outbreaks in western Montana. Forest Ecology and Management. 22(3-4): 251-260. doi:10.1016/0378-1127(87)90109-5

Anderson, R.C.; Loucks, O.L.; Swain, A.M. 1969. Herbaceous response to canopy cover, light intensity, and throughfall precipitation in coniferous forests. Ecology. 50(2): 255-263. doi:10.2307/1934853

Andrews, P.L.; Williams, J.T. 1998. Fire potential evaluation in support of prescribed fire risk assessment. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL: Tall Timbers Research Station: 64-68. https://talltimbers.org/wp-content/uploads/2018/09/64-AndrewsandWilliams1998_op.pdf

Aney, W.C. 1984. Effects of patch size on bird communities of remnant old-growth pine stands in western Montana. M.S. thesis. Missoula, MT: University of Montana. 98 p. https://scholarworks.umt.edu/etd/2186

Angell, R.F.; Miller, R.F. 1994. Simulation of leaf conductance and transpiration in *Juniperus occidentalis*. Forest Science. 40(1): 5-17. doi:10.1093/forestscience/40.1.5

Aplet, G.H. 1994. Beyond even- vs. uneven-aged management: Toward a cohort-based silviculture. Journal of Sustainable Forestry. 2(3-4): 423-433. doi:10.1300/J091v02n03_12

Aplet, G.H.; Keeton, W.S. 1999. Application of historical range of variability concepts to biodiversity conservation. Chapter 5. In: Baydack, R.K.; Campa, H. III; Haufler, J.B., eds. Practical approaches to the conservation of biological diversity. Washington, DC: Island Press: 71-86. isbn:1-55963-544-4

Aplet, G.H.; Laven, R.D.; Fiedler, P.L. 1992. The relevance of conservation biology to natural resource management. Conservation Biology. 6(2): 298-300. www.jstor.org/stable/2386253

Arkle, R.S.; Pilliod, D.S. 2010. Prescribed fires as ecological surrogates for wildfires: A stream and riparian perspective. Forest Ecology and Management. 259(5): 893-903. doi:10.1016/j.foreco.2009.11.029

Arkle, R.S.; Pilliod, D.S.; Welty, J.L. 2012. Pattern and process of prescribed fires influence effectiveness at reducing wildfire severity in dry coniferous forests. Forest Ecology and Management. 276: 174-184. doi:10.1016/j.foreco.2012.04.002

Armleder, H. 1999. Clumpy spacing: Juvenile spacing Douglas-fir into clumps to imitate natural stand structure. Extension Note 32. Victoria, BC: British Columbia Ministry of Forests. 6 p. https://www.for.gov.bc.ca/hfd/pubs/docs/en/en32.pdf

Armour, C.D.; Bunting, S.C.; Neuenschwander, L.F. 1984. Fire intensity effects on the understory in ponderosa pine forests. Journal of Range Management. 37(1): 44-49. https://journals.uair.arizona.edu/index.php/jrm/article/view/7667/7279

Arneth, A.; Sitch, S.; Pongratz, J.; Stocker, B.D.; Ciais, P.; Poulter, B.; Bayer, A.D.; Bondeau, A.; Calle, L.; Chini, L.P.; Gasser, T.; Fader, M.; Friedlingstein, P.; Kato, E.; Li, W.; Lindeskog, M.; Nabel, J.E.M.S.; Pugh, T.A.M.; Robertson, E.; Viovy, N.; Yue, C.; Zaehle, S. 2017. Historical carbon dioxide emissions caused by land-use changes are possibly larger than assumed. Nature Geoscience. 10(2): 79-84. doi:10.1038/ngeo2882

Arno, S.F. 1980. Forest fire history in the northern Rockies. Journal of Forestry. 78(8): 460-465. doi:10.1093/jof/78.8.460

Arno, S.F. 1988. Fire ecology and its management implications in ponderosa pine forests. In: Baumgartner, D.M.; Lotan, J.E., comps. Ponderosa pine: the species and its management; symposium proceedings. Pullman, WA: Washington State University, Depart. of Natural Resource Sciences, Cooperative Extension: 133-139.

Arno, M.K. 1996. Reestablishing fire-adapted communities to riparian forests in the ponderosa pine zone. In: Hardy, C.C.; Arno, S.F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station: 42-43. https://www.fs.usda.gov/treesearch/pubs/28489

Arno, S.F. 1996. The concept: Restoring ecological structure and process in ponderosa pine forests. In: Hardy, C.C.; Arno, S.F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station: 37-38. https://www.fs.usda.gov/treesearch/pubs/28486

Arno, S.F.; Allison-Bunnell, S. 2002. Flames in our forest: Disaster or renewal? Washington, DC: Island Press. 227 p. isbn:1-55963-883-4

Arno, S.F.; Allison-Bunnell, S. 2003. Managing fire-prone forests: Roots of our dilemma. Fire Management Today. 63(2): 12-16. https://www.fs.fed.us/file/40954/download?token=kYI6rtgO

Arno, S.F.; Brown, J.K. 1991. Overcoming the paradox in managing wildland fire. Western Wildlands. 17(1): 40-46.

Arno, S.F.; Fiedler, C.E. 2005. Mimicking nature's fire: Restoring fire-prone forests in the West. Washington, DC: Island Press. 242 p. isbn:1-55963-143-0

Arno, S.F.; Harrington, M.G. 1998. The interior west: Managing fire-dependent forests by simulating natural disturbance regimes. In: Forest management into the next century: what will make it work? Madison, WI: Forest Products Society: 53-62.

Arno, S.F.; Ostlund, L.; Keane, R.E. 2008. Living artifacts: The ancient ponderosa pines of the West. Montana: The Magazine of Western History. Spring: 55-67. https://www.fs.usda.gov/treesearch/pubs/30646

Arno, S.F.; Ottmar, R.D. 1994. Reducing hazard for catastrophic fire. In: Everett, R.L., comp. Volume IV: restoration of stressed sites, and processes. Gen. Tech. Rep. PNW-GTR-330. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 18-19. doi:10.2737/PNW-GTR-330

Arno, S.F.; Sneck, K.M. 1977. A method for determining fire history in coniferous forests of the mountain west. Gen. Tech. Rep. INT-42. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 28 p. https://www.fs.usda.gov/treesearch/pubs/29572

Arno, S.F.; Scott, J.H.; Hartwell, M.G. 1995a. Age-class structure of old growth ponderosa pine/ Douglas-fir stands and its relationship to fire history. Res. Pap. INT-RP-481. Ogden, UT: USDA Forest Service, Intermountain Research Station. 25 p. https://www.fs.fed.us/rm/pubs/rmrs_gtr292/int_rp481.pdf

Arno, S.F.; Harrington, M.G.; Fiedler, C.E.; Carlson, C.E. 1995b. Restoring fire-dependent ponderosa pine forests in western Montana. Restoration and Management Notes. 13(1): 32-36. doi:10.3368/er.13.1.32

Arno, S.F.; Harrington, M.G.; Fiedler, C.E.; Carlson, C.E. 1996. Using silviculture and prescribed fire to reduce fire hazard and improve health in ponderosa pine forests. In: Proceedings of the seventeenth annual forest vegetation management conference; 1996 January 16-18; Redding, CA: 114-118. http://www.fvmc.org/PDF/FVMCProc17th(1996).pdf

Arno, S.F.; Smith, H.Y.; Krebs, M.A. 1997. Old growth ponderosa pine and western larch stand structures: Influences of pre-1900 fires and fire exclusion. Res. Pap. INT-RP-495. Ogden, UT: USDA Forest Service, Intermountain Research Station. 20 p. https://www.fs.fed.us/rm/pubs/rmrs_gtr292/int_rp495.pdf

Arno, S.F.; Parsons, D.J.; Keane, R.E. 2000. Mixed-severity fire regimes in the northern Rocky Mountains: consequences of fire exclusion and options for the future. In: Cole, D.N.; McCool, S.F.; Borrie, W.T.; O'Loughlin, J., comps. Wilderness science in a time of change conference-Volume 5: Wilderness ecosystems, threats, and management. Proceedings RMRS-P-15-VOL-5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 225-232. http://www.treesearch.fs.fed.us/pubs/21867

Arno, S.F.; Fiedler, C.E.; Arno, M.K. 2008. "Giant pines and grassy glades:" The historic ponderosa pine ecosystem, disappearing icon of the American west. Forest History Today. Spring: 12-19. https://foresthistory.org/wp-content/uploads/2016/12/2008-Spring_giant-pines.pdf

Arno, S.F.; Ostlund, L.; Keane, R.E. 2008. Living artifacts: The ancient ponderosa pines of the West. Montana: The Magazine of Western History. Spring: 55-67. https://www.fs.usda.gov/treesearch/pubs/30646

Attiwill, P.M. 1994. The disturbance of forest ecosystems: The ecological basis for conservative management. Forest Ecology and Management. 63(2-3): 247-300. doi:10.1016/0378-1127(94)90114-7

Auclair, A.N.D.; Bedford, J.A. 1994. Conceptual origins of catastrophic forest mortality in the western United States. Journal of Sustainable Forestry. 2(3-4): 249-265. doi:10.1300/J091v02n03_02

Averett, J.P.; Endress, B.A.; Rowland, M.M.; Naylor, B.J.; Wisdom, M.J. 2017. Wild ungulate herbivory suppresses deciduous woody plant establishment following salmonid stream restoration. Forest Ecology and Management. 391(Supplement C): 135-144. doi:10.1016/j.foreco.2017.02.017

Averett, J.P.; Wisdom, M.J.; Endress, B.A. 2019. Livestock riparian guidelines may not promote woody species recovery where wild ungulate populations are high. Rangeland Ecology & Management. 72(1): 145-149. doi:10.1016/j.rama.2018.07.008

Avery, C.C.; Larson, F.R.; Schubert, G.H. 1976. Fifty-year records of virgin stand development in southwestern ponderosa pine. Gen. Tech. Rep. RM-22. Fort Collins, CO: USDA Rocky Mountain Forest and Range Experiment Station. 71 p. https://archive.org/download/CAT76677471/CAT76677471.pdf

Axelton, E.A. 1967. Ponderosa pine bibliography through 1965. Res. Pap. INT-40. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 150 p. https://archive.org/download/ponderosapinebib40axel/ponderosapinebib40axel.pdf

Azuma, D.L.; Hiserote, B.A.; Dunham, P.A. 2005. The western juniper resource of eastern Oregon. Res. Bull. PNW-RB-249. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 18 p. http://www.treesearch.fs.fed.us/pubs/21051

Backer, D.M.; Jensen, S.E.; McPherson, G.R. 2004. Impacts of fire-suppression activities on natural communities. Conservation Biology. 18(4): 937-946. doi:10.1111/j.1523-1739.2004.494_1.x

Bagdon, B.A.; Huang, C.-H.; Dewhurst, S.; Meador, A.S. 2017. Climate change constrains the efficiency frontier when managing forests to reduce fire severity and maximize carbon storage. Ecological Economics. 140: 201-214. doi:10.1016/j.ecolecon.2017.05.016

Bailey, J.D.; Covington, W.W. 2002. Evaluating ponderosa pine regeneration rates following ecological restoration treatments in northern Arizona, USA. Forest Ecology and Management. 155(1-3): 271-278. doi:10.1016/S0378-1127(01)00564-3

Baker, F.S. 1925. Character of the soil in relation to the reproduction of western yellow pine. Journal of Forestry. 23(7-8): 630-634. doi:10.1093/jof/23.7.630

Baker, W.L. 1992. Effects of settlement and fire suppression on landscape structure. Ecology. 73(5): 1879-1887. doi:10.2307/1940039

Baker, W.L. 1994. Restoration of landscape structure altered by fire suppression. Conservation Biology. 8(3): 763-769. doi:10.1046/j.1523-1739.1994.08030763.x

Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. Ecosphere. 3(3): art23 (39 p). doi:10.1890/es11-00320.1

Baker, W.L. 2015. Are high-severity fires burning at much higher rates recently than historically in dry-forest landscapes of the western USA? PLoS ONE. 10(9): e0136147 (26 p). doi:10.1371/journal.pone.0136147

Baker, W.L.; Dugan, A.J. 2013. Fire-history implications of fire scarring. Canadian Journal of Forest Research. 43(10): 951-962. doi:10.1139/cjfr-2013-0176

Baker, W.L.; Ehle, D. 2001. Uncertainty in surface-fire history: The case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research. 31(7): 1205-1226. doi:10.1139/x01-046

Baker, F.S.; Korstian, C.F. 1931. Suitability of brush lands in the Intermountain Region for the growth of natural or planted western yellow pine forests. Tech. Bull. No. 256. Washington, DC: U.S. Department of Agriculture. 83 p. https://naldc.nal.usda.gov/download/CAT86200250/PDF

Baker, W.L.; Williams, M.A. 2018. Land surveys show regional variability of historical fire regimes and dry forest structure of the western United States. Ecological Applications. 28(2): 284-290. doi:10.1002/eap.1688

Baker, D.L.; Andelt, W.F.; Burnham, K.P.; Shepperd, W.D. 1999. Effectiveness of Hot Sauce® and Deer Away® repellents for deterring elk browsing of aspen sprouts. Journal of Wildlife Management. 63(4): 1327-1336. doi:10.2307/3802851

Baker, W.L.; Veblen, T.T.; Sherriff, R.L. 2007. Fire, fuels and restoration of ponderosa pine-Douglas fir forests in the Rocky Mountains, USA. Journal of Biogeography. 34(2): 251-269. doi:10.1111/j.1365-2699.2006.01592.x

Bakker, J.D. 2005. A new, proportional method for reconstructing historical tree diameters. Canadian Journal of Forest Research. 35(10): 2515-2520. doi:10.1139/x05-136

Bakker, J.D.; Moore, M.M. 2007. Controls on vegetation structure in southwestern ponderosa pine forests, 1941 and 2004. Ecology. 88(9): 2305-2319. doi:10.1890/06-1775.1

Bailey, R.G. 1995. Description of the ecoregions of the United States. Misc. Pub. 1391. Washington, DC: USDA Forest Service. 108 p. https://archive.org/download/descriptionofeco1391bail/descriptionofeco1391bail.pdf

Bailey, R.G. 1998. Ecoregions map of North America: Explanatory note. Misc. Pub. No. 1548. Washington, DC: USDA Forest Service. 10 p. https://archive.org/download/ecoregionsmapofn1548bail/ecoregionsmapofn1548bail.pdf

Bailey, J.D.; Covington, W.W. 2002. Evaluating ponderosa pine regeneration rates following ecological restoration treatments in northern Arizona, USA. Forest Ecology and Management. 155(1-3): 271-278. doi:10.1016/S0378-1127(01)00564-3

Barbouletos, C.S.; Morelan, L.Z.; Carrol, F.O. 1998. We will not wait: Why prescribed fire must be implemented on the Boise National Forest. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL: Tall Timbers Research Station: 27-30. https://talltimbers.org/wp-content/uploads/2018/09/27-Barbouletosetal1998_op.pdf

Barbour, R.J.; Skog, K.E., eds. 1997. Role of wood production in ecosystem management: proceedings of the sustainable forestry working group at the IUFRO A11 Division 5 conference. Gen. Tech. Rep. FPL-GTR-100. Madison, WI: USDA Forest Service, Forest Products Lab. 98 p. https://www.fs.usda.gov/treesearch/pubs/5659

Barbour, M.; Kelley, E.; Maloney, P.; Rizzo, D.; Royce, E.; Fites-Kaufmann, J. 2002. Present and past old-growth forests of the Lake Tahoe Basin, Sierra Nevada, US. Journal of Vegetation Science. 13(4): 461-472. doi:10.1111/j.1654-1103.2002.tb02073.x

Barbour, R.J.; Singleton, R.; Maguire, D.A. 2007. Evaluating forest product potential as part of planning ecological restoration treatments on forested landscapes. Landscape and Urban Planning. 80(3): 237-248. doi:10.1016/j.landurbplan.2006.12.003

Barbour, J.; Countryman, B.; Fight, R.; Justice, D.; McArthur, W.; Powell, D.; Rockwell, V.; Singleton, R.; Uebler, E. 2008. Chapter 5: The effect of new and proposed policy changes on managers' ability to thin densely stocked stands and reduce fire risk. In: Rainville, R.; White, R.; Barbour, J., tech. eds. Assessment of timber availability from forest restoration within the

Blue Mountains of Oregon. Gen. Tech. Rep. PNW-GTR-752. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 65 p. http://www.treesearch.fs.fed.us/pubs/30559

Barnes, B.V. 1975. Phenotypic variation of trembling aspen in western North America. Forest Science. 21(3): 319-328. doi:10.1093/forestscience/21.3.319

Baron, F.J. 1962. Effects of different grasses on ponderosa pine seedling establishment. Res. Note No. 199. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 8 p. https://www.nal.usda.gov/exhibits/speccoll/items/show/4573

Barrett, J.W. 1963. Dominant ponderosa pines do respond to thinning. Res. Note PNW-9. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p. https://archive.org/download/dominantponderos09barr/dominantponderos09barr.pdf

Barrett, J.W. 1968. Response of ponderosa pine pole stands to thinning. Res. Note PNW-77. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 11 p. https://archive.org/download/responseofponder77barr/responseofponder77barr.pdf

Barrett, J.W. 1970. Ponderosa pine saplings respond to control of spacing and understory vegetation. Res. Pap. PNW-106. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p. https://archive.org/download/CAT92272826/CAT92272826.pdf

Barrett, J.W. 1972. Large-crowned planted ponderosa pine respond well to thinning. Res. Note PNW-179. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p. Barrett 1972

Barrett, J.W. 1979. Silviculture of ponderosa pine in the Pacific Northwest: The state of our knowledge. Gen. Tech. Rep. PNW-97. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 106 p. https://archive.org/download/SilvicultureOfPonderosaPineInThePacificNorthwestTheStateOfOur/silverculture.pdf

Barrett, S.W. 1980. Indians and fire. Western Wildlands. 6(3): 17-21.

Barrett, S.W. 1988. Fire suppression's effects on forest succession within a central Idaho wilderness. Western Journal of Applied Forestry. 3(3): 76-80. doi:10.1093/wjaf/3.3.76

Barrett, S.W.; Arno, S.F. 1982. Indian fires as an ecological influence in the northern Rockies. Journal of Forestry. 80(10): 647-651. doi:10.1093/jof/80.10.647

Barrett, S.W.; Arno, S.F.; Menakis, J.P. 1997. Fire episodes in the inland northwest (1540-1940) based on fire history data. Gen. Tech. Rep. INT-GTR-370. Ogden, UT: USDA Forest Service, Intermountain Research Station. 17 p. https://www.fs.usda.gov/treesearch/pubs/34303

Barrett, S.; Havlina, D.; Jones, J.; Hann, W.; Frame, C.; Hamilton, D.; Schon, K.; Demeo, T.; Hutter, L.; and Menakis, J. 2010. Interagency Fire Regime Condition Class guidebook. Version 3.0 [Homepage of the Interagency Fire Regime Condition Class website, USDA Forest Service, US Department of the Interior, and The Nature Conservancy]. [Online], Available: www.frcc.gov

Barros, A.M.G.; Ager, A.A.; Day, M.A.; Palaiologou, P. 2019. Improving long-term fuel treatment effectiveness in the National Forest System through quantitative prioritization. Forest Ecology and Management. 433: 514-527. doi:10.1016/j.foreco.2018.10.041

Barrows, C.W.; Ramirez, A.R.; Sweet, L.C.; Morelli, T.L.; Millar, C.I.; Frakes, N.; Rodgers, J.; Mahalovich, M.F. 2020. Validating climate-change refugia: empirical bottom-up approaches to support management actions. Frontiers in Ecology and the Environment. 18(5): 298-306. doi:10.1002/fee.2205

Barth, M.A.F.; Larson, A.J.; Lutz, J.A. 2015. A forest reconstruction model to assess changes to Sierra Nevada mixed-conifer forest during the fire suppression era. Forest Ecology and Management. 354: 104-118. doi:10.1016/j.foreco.2015.06.030

Bartlett, A.A. 1994. Reflections on sustainability, population growth, and the environment. Population and Environment. 16(1): 5-35. www.jstor.org/stable/27503374

Bartos, D.L.; Campbell, R.B., Jr. 1998. Water depletion and other ecosystem values forfeited when conifer forests displace aspen communities. In: Potts, D.F., ed. Proceedings of the AWRA specialty conference, rangeland management and water resources. TPS-98-1. Herndon, VA: American Water Resources Association: 427-434.

Bartuszevige, A.M.; Kennedy, P.L. 2009. Synthesis of knowledge on the effects of fire and thinning treatments on understory vegetation in U.S. dry forests. Special Rep. 1095. Corvallis, OR: Oregon State University, Extension and Experiment Station Communications. 132 p. fire_thinning_effects_understory_vegetation

Baskerville, G.L. 1975. Spruce budworm: Super silviculturist. Forestry Chronicle. 51(4): 138-140. doi:10.5558/tfc51138-4

Bataineh, A.L.; Oswald, B.P.; Bataineh, M.M.; Williams, H.M.; Coble, D.W. 2006. Changes in understory vegetation of a ponderosa pine forest in northern Arizona 30 years after a wildfire. Forest Ecology and Management. 235(1-3): 283-294. doi:10.1016/j.foreco.2006.09.003

Bate, L.J.; Wisdom, M.J.; Wales, B.C. 2007. Snag densities in relation to human access and associated management factors in forests of northeastern Oregon, USA. Landscape and Urban Planning. 80(3): 278-291. doi:10.1016/j.landurbplan.2006.10.008

Battaglia, M.A.; Smith, F.W.; Shepperd, W.D. 2008. Can prescribed fire be used to maintain fuel treatment effectiveness over time in Black Hills ponderosa pine forests? Forest Ecology and Management. 256(12): 2029-2038. doi:10.1016/j.foreco.2008.07.026

Battaglia, M.; Smith, F.W.; Shepperd, W.D. 2009. Predicting mortality of ponderosa pine regeneration after prescribed fire in the Black Hills, South Dakota, USA. International Journal of Wildland Fire. 18(2): 176-190. doi:10.1071/WF07163

Battaglia, M.A.; Gannon, B.; Brown, P.M.; Fornwalt, P.J.; Cheng, A.S.; Huckaby, L.S. 2018. Changes in forest structure since 1860 in ponderosa pine dominated forests in the Colorado and Wyoming Front Range, USA. Forest Ecology and Management. 422: 147-160. doi:10.1016/j.foreco.2018.04.010

Battles, J.J.; Shlisky, A.J.; Barrett, R.H.; Heald, R.C.; Allen-Diaz, B.H. 2001. The effects of forest management on plant species diversity in a Sierran conifer forest. Forest Ecology and Management. 146(1-3): 211-222. doi:10.1016/S0378-1127(00)00463-1

Battles, J.J.; Robards, T.; Das, A.; Waring, K.; Gilless, J.K.; Biging, G.; Schurr, F. 2008. Climate change impacts on forest growth and tree mortality: a data-driven modeling study in the mixed-conifer forest of the Sierra Nevada, California. Climatic Change. 87(1): 193-213. doi:10.1007/s10584-007-9358-9

Bauhus, J.; Puettmann, K.; Messier, C. 2009. Silviculture for old-growth attributes. Forest Ecology and Management. 258(4): 525-537. doi:10.1016/j.foreco.2009.01.053

Baumgartner, D.M.; Lotan, J.E. 1988. Ponderosa pine: the species and its management. Pullman, WA: Washington State University, Cooperative Extension: 281 p.

Baydack, R.K.; Campa, H.; Haufler, J.B., eds. 1999. Practical approaches to the conservation of biological diversity. Washington, DC: Island Press. 313 p. isbn:1-55963-544-4

Beatty, J.S.; Mathiasen, R.L. 2003. Dwarf mistletoes of ponderosa pine. Forest Insect & Disease Leaflet 40; R6-NR-FID-PR-01. [Place of publication unknown]: USDA Forest Service. 8 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043648.pdf

Beatty, J.S.; Filip, G.M.; Mathiasen, R.L. [1997]. Larch dwarf mistletoe. Forest Insect & Disease Leaflet 169; R6-FID-PR-009-97. [Place of publication unknown]: USDA Forest Service. 7 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043215.pdf

Beckham, S.D. 1991. The Grande Ronde Valley and Blue Mountains: Impressions and experiences of travelers and emigrants, the Oregon Trail, 1812-1880. Beckham and Associates Rep. No. 2. Lake Oswego, OR: Beckham and Associates. 104 p. (plus 111-page appendix). https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd482690.pdf

Beechie, T.J.; Sear, D.A.; Olden, J.D.; Pess, G.R.; Buffington, J.M.; Moir, H.; Roni, P.; Pollock, M.M. 2010. Process-based principles for restoring river ecosystems. BioScience. 60(3): 209-222. doi:10.1525/bio.2010.60.3.7

Beier, P.; Brost, B. 2010. Use of land facets to plan for climate change: Conserving the arenas, not the actors. Conservation Biology. 24(3): 701-710. doi:10.1111/j.1523-1739.2009.01422.x

Belote, R.T.; Larson, A.J.; Dietz, M.S. 2015. Tree survival scales to community-level effects following mixed-severity fire in a mixed-conifer forest. Forest Ecology and Management. 353: 221-231. doi:10.1016/j.foreco.2015.05.033

Belsky, A.J. 1996. Western juniper expansion: Is it a threat to arid northwestern ecosystems? Journal of Range Management. 49(1): 53-59. https://journals.uair.arizona.edu/index.php/jrm/article/download/9085/8697

Belsky, A.J.; Blumenthal, D.M. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the interior west. Conservation Biology. 11(2): 315-327. doi:10.1046/j.1523-1739.1997.95405.x

Bennett, R.S. 2000. Extremists are destroying our national forests. 21st Century Science and Technology. 13(3): 66-68, 70. https://21sci-tech.com/Subscriptions/Archive/2000_F.pdf

Bennett, L.T.; Bruce, M.J.; Machunter, J.; Kohout, M.; Krishnaraj, S.J.; Aponte, C. 2017. Assessing fire impacts on the carbon stability of fire-tolerant forests. Ecological Applications. 27(8): 2497-2513. doi:10.1002/eap.1626

Bennetts, R.E.; White, G.C.; Hawksworth, F.G.; Severs, S.E. 1996. The influence of dwarf mistletoe on bird communities in Colorado ponderosa pine forests. Ecological Applications. 6(3): 899-909. doi:10.2307/2269493

Benson, R.E.; Ullrich, J.R. 1981. Visual impacts of forest management activities: Findings on public preferences. Res. Pap. INT-262. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 14 p. https://archive.org/download/visualimpactsoff262bens/visualimpactsoff262bens.pdf

Berndt, H.W.; Gibbons, R.D. 1958. Root distribution of some native trees and understory plants growing on three sites within ponderosa pine watersheds in Colorado. Station Pap. No. 37. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 14 p. https://archive.org/download/rootdistribution37bern/rootdistribution37bern.pdf

Beschta, R.L.; Ripple, W.J. 2020. Large carnivore extirpation linked to loss of overstory aspen in Yellowstone. Food Webs. 22: e00140 (7 p). doi:10.1016/j.fooweb.2019.e00140

Beschta, R.L.; Rhodes, J.J.; Kauffman, J.B.; Gresswell, R.E.; Minshall, G.W.; Karr, J.R.; Perry, D.A.; Hauer, F.R.; Frissell, C.A. 2004. Postfire management on forested public lands of the western United States. Conservation Biology. 18(4): 957-967.

doi:10.1111/j.1523-1739.2004.00495.x

Betts, B.J. 1998. Roosts used by maternity colonies of silver-haired bats in northeastern Oregon. Journal of Mammalogy. 79(2): 643-650. doi:10.2307/1382994

Bigelow, S.W.; North, M.P. 2012. Microclimate effects of fuels-reduction and group-selection silviculture: implications for fire behavior in Sierran mixed-conifer forests. Forest Ecology and Management. 264: 51-59. doi:10.1016/j.foreco.2011.09.031

Bigelow, S.W.; North, M.P.; Salk, C.F. 2011. Using light to predict fuels-reduction and group-selection effects on succession in Sierran mixed-conifer forest. Canadian Journal of Forest Research. 41(10): 2051-2063. doi:10.1139/x11-120

Biggs, R.; Carpenter, S.R.; Brock, W.A. 2009. Turning back from the brink: Detecting an impending regime shift in time to avert it. Proceedings of the National Academy of Sciences. 106(3): 826-831. doi:10.1073/pnas.0811729106

Binkley, D.; Adams, M.; Fredericksen, T.; Laclau, J.P.; Mäkinen, H.; Prescott, C. 2018. Connecting ecological science and management in forests for scientists, managers and pocket scientists. Forest Ecology and Management. 410: 157-163. doi:10.1016/j.foreco.2017.11.022

Birdsey, R.A.; Dugan, A.J.; Healey, S.P.; Dante-Wood, K.; Zhang, F.; Mo, G.; Chen, J.M.; Hernandez, A.J.; Raymond, C.L.; McCarter, J. 2019. Assessment of the influence of disturbance, management activities, and environmental factors on carbon stocks of U.S. national forests. Gen. Tech. Rep. RMRS-GTR-402. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 116 p. https://www.fs.usda.gov/treesearch/pubs/59157

Biswell, H.H. 1973. Fire ecology in ponderosa pine-grassland. Proceedings of the 12th annual Tall Timbers fire ecology conference. Tallahassee, FL: Tall Timbers Research Station: 69-96. https://talltimbers.org/wp-content/uploads/2018/09/69-Biswell1972_op.pdf

Blackwood, J. 2003 (September 5). Guidance for implementing Eastside Screens. Memorandum to S.O. Staff and District Rangers. Pendleton, OR: USDA Forest Service, Umatilla National Forest, Supervisor's Office. 7 p.

Blake, J.G. 1982. Influence of fire and logging on nonbreeding bird communities of ponderosa pine forests. Journal of Wildlife Management. 46(2): 404-415. doi:10.2307/3808652

Blanchette, R.A.; Shaw, C.G. 1978. Management of forest residues for rapid decay. Canadian Journal of Botany. 56(22): 2904-2909. doi:10.1139/b78-348

Blicharska, M.; Mikusinski, G. 2014. Incorporating social and cultural significance of large old trees in conservation policy. Conservation Biology. 28(6): 1558-1567. doi:10.1111/cobi.12341

Block, W.M.; Finch, D.M. 1997. Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 152 p. https://www.fs.usda.gov/treesearch/pubs/20752

Blomdahl, E.M.; Kolden, C.A.; Meddens, A.J.H.; Lutz, J.A. 2019. The importance of small fire refugia in the central Sierra Nevada, California, USA. Forest Ecology and Management. 432: 1041-1052. doi:10.1016/j.foreco.2018.10.038

Boag, A.E.; Hamilton, L.C.; Hartter, J.; Stevens, F.R.; Palace, M.W.; Ducey, M.J. 2016. Shifting environmental concern in rural eastern Oregon: The role of demographic and place-based factors. Population and Environment. 38(2): 207-216. doi:10.1007/s11111-016-0261-z

Boag, A.E.; Ducey, M.J.; Palace, M.W.; Hartter, J. 2020. Topography and fire legacies drive variable post-fire juvenile conifer regeneration in eastern Oregon, USA. Forest Ecology and Management. 474: 118312 (13 p). doi:10.1016/j.foreco.2020.118312

Boerker, R.H. 1912. Light burning versus forest management in northern California. Journal of Forestry. 10(2): 184-194. doi:10.1093/jof/10.2.184

Boerker, R.H.D. 1920. Our national forests, a short popular account of the work of the United States Forest Service on the national forests. New York: Macmillan Company. 238 p. ournationalfores1918boer/ournationalfores1918boer.pdf

Boerner, R.E.J.; Huang, J.; Hart, S.C. 2009. Impacts of fire and fire surrogate treatments on forest soil properties: A meta-analytical approach. Ecological Applications 19(2): 338-358. doi:10.1890/07-1767.1

Boisramé, G.; Thompson, S.; Collins, B.; Stephens, S. 2017. Managed wildfire effects on forest resilience and water in the Sierra Nevada. Ecosystems. 20(4): 717-732. doi:10.1007/s10021-016-0048-1

Boisramé, G.; Thompson, S.; Stephens, S. 2018. Hydrologic responses to restored wildfire regimes revealed by soil moisture-vegetation relationships. Advances in Water Resources. 112: 124-146. doi:10.1016/j.advwatres.2017.12.009

Boldt, C.E.; Van Deusen, J.L. 1974. Silviculture of ponderosa pine in the Black Hills: the status of our knowledge. Res. Pap. RM-124. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 45 p. https://www.fs.usda.gov/treesearch/pubs/48208

Bolon, N.A. 1994. Estimates of the values of elk in the Blue Mountains of Oregon and Washington: evidence from the existing literature. Gen. Tech. Rep. PNW-GTR-316. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 38 p. https://www.fs.usda.gov/treesearch/pubs/9059

Bolsinger, C.L.; Berger, J.M. 1975. The timber resources of the Blue Mountain area, Oregon. Res. Bull. PNW-57. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 62 p. https://www.fs.usda.gov/treesearch/pubs/26295

Bond, W.J.; Keeley, J.E. 2005. Fire as a global 'herbivore': The ecology and evolution of flammable ecosystems. Trends in Ecology and Evolution. 20(7): 387-394. doi:10.1016/j.tree.2005.04.025

Bond, W.J.; Midgley, J.J. 1995. Kill thy neighbor: An individualistic argument for the evolution of flammability. Oikos. 73(1): 79-85. doi:10.2307/3545728

Bond, W.J.; Woodward, F.I.; Midgley, G.F. 2005. The global distribution of ecosystems in a world without fire. New Phytologist. 165(2): 525-538. doi:10.1111/j.1469-8137.2004.01252.x

Bonnet, V.H.; Schoettle, A.W.; Shepperd, W.D. 2005. Postfire environmental conditions influence the spatial pattern of regeneration for *Pinus ponderosa*. Canadian Journal of Forest Research. 35(1): 37-47. doi:10.1139/x04-157

Bonnicksen, T.M. 2000a. America's ancient forests: from the ice age to the age of discovery. New York: John Wiley & Sons. 594 p. isbn:0-471-13622-0

Bonnicksen, T.M. 2000b. Our forests need 'active management.' 21st Century Science and Technology. 13(3): 68-69. https://21sci-tech.com/Subscriptions/Archive/2000_F.pdf

Borman, M.M. 2005. Forest stand dynamics and livestock grazing in historical context. Conservation Biology. 19(5): 1658-1662. doi:10.1111/j.1523-1739.2005.00115.x

Bormann, F.H.; Likens, G.E. 1979. Pattern and process in a forested ecosystem: Disturbance, development, and the steady state based on the Hubbard Brook ecosystem study. New York: Springer-Verlag. 253 p. isbn:0-38-790321-6

Bosch, J.M.; Hewlett, J.D. 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. Journal of Hydrology. 55(1-4): 3-23. doi:10.1016/0022-1694(82)90117-2

Botkin, D.B. 1990. Discordant harmonies: A new ecology for the twenty-first century. New York: Oxford University Press. 241 p. isbn:0-19-507469-6

Botkin, D.B. 1995. Our natural history: The lessons of Lewis and Clark. New York: G.P. Putnam's Sons. 300 p. isbn:0-399-14048-4

Bowman, D.M.J.S.; Balch, J.K.; Artaxo, P.; Bond, W.J.; Carlson, J.M.; Cochrane, M.A.; D'Antonio, C.M.; DeFries, R.S.; Doyle, J.C.; Harrison, S.P.; Johnston, F.H.; Keeley, J.E.; Krawchuk, M.A.; Kull, C.A.; Marston, J.B.; Moritz, M.A.; Prentice, I.C.; Roos, C.I.; Scott, A.C.; Swetnam, T.W.; van der Werf, G.R.; Pyne, S.J. 2009. Fire in the Earth system. Science. 324(5926): 481-484. doi:10.1126/science.1163886

Boyd, R. 1999. Indians, fire, and the land in the Pacific Northwest. Corvallis, OR: Oregon State University Press. 313 p. isbn:0-87071-459-7

Boyden, S.; Binkley, D.; Shepperd, W. 2005. Spatial and temporal patterns in structure, regeneration, and mortality of an old-growth ponderosa pine forest in the Colorado Front Range. Forest Ecology and Management. 219(1): 43-55. doi:10.1016/j.foreco.2005.08.041

Boyle, S.I.; Hart, S.C.; Kaye, J.P.; Waldrop, M.P. 2005. Restoration and canopy type influence soil microflora in a ponderosa pine forest. Soil Science Society of America Journal. 69(5): 1627-1638. doi:10.2136/sssaj2005.0029

Bradford, J.B.; Bell, D.M. 2017. A window of opportunity for climate-change adaptation: Easing tree mortality by reducing forest basal area. Frontiers in Ecology and the Environment. 15(1): 11-17. doi:10.1002/fee.1445

Bradley, C.M.; Hanson, C.T.; DellaSala, D.A. 2016. Does increased forest protection correspond to higher fire severity in frequent-fire forests of the western United States? Ecosphere. 7(10): e01492 (13 p). doi:10.1002/ecs2.1492

Brandes, D.; Wilcox, B.P. 2000. Evapotranspiration and soil moisture dynamics on a semiarid ponderosa pine hillslope. Journal of the American Water Resources Association. 36(5): 965-974. doi:10.1111/j.1752-1688.2000.tb05702.x

Breece, C.R.; Kolb, T.E.; Dickson, B.G.; McMillin, J.D.; Clancy, K.M. 2008. Prescribed fire effects on bark beetle activity and tree mortality in southwestern ponderosa pine forests. Forest Ecology and Management. 255(1): 119-128. doi:10.1016/j.foreco.2007.08.026

Brice, E.M.; Miller, B.A.; Zhang, H.; Goldstein, K.; Zimmer, S.N.; Grosklos, G.J.; Belmont, P.; Flint, C.G.; Givens, J.E.; Adler, P.B.; Brunson, M.W.; Smith, J.W. 2020. Impacts of climate change on multiple use management of Bureau of Land Management land in the Intermountain West, USA. Ecosphere. 11(11): e03286 (29 p). doi:10.1002/ecs2.3286

Briggs, J.S.; Hawbaker, T.J.; Vandendriesche, D. 2015. Resilience of ponderosa and lodgepole pine forests to mountain pine beetle disturbance and limited regeneration. Forest Science. 61(4): 689-702. doi:10.5849/forsci.14-192

Briggs, J.S.; Fornwalt, P.J.; Feinstein, J.A. 2017. Short-term ecological consequences of collaborative restoration treatments in ponderosa pine forests of Colorado. Forest Ecology and Management. 395: 69-80. doi:10.1016/j.foreco.2017.03.008

Bright, G.A. 1912. A study of the growth of yellow pine in Oregon. Unpublished typescript report obtained from National Archives, College Park, Maryland; record group 95. 106 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5394377.pdf

Bright, G.A. 1914a. The extensive reconnaissance of the Wenaha National Forest. Unpublished typescript report obtained from National Archives, College Park, Maryland; record group 95. 84 p.

Bright, G.A. 1914b. The relation of crown space to the volume of present and future stands of western yellow pine. Forestry Quarterly [Journal of Forestry]. 12(3): 330-340. doi:10.1093/jof/12.3.330

Bright, G.A.; Powell, David C. (ed.). 2008. An extensive reconnaissance of the Wenaha National Forest in 1913. Tech. Pub. F14-SO-06-08. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 65 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015522.pdf

Brock, G.; Brock, L. 1993. Snapshot in time: Repeat photography on the Boise National Forest, 1870-1992. Boise, ID: USDA Forest Service, Intermountain Region, Boise National Forest. 239 p. http://digitalcommons.usu.edu/govdocs_forest/2/

Brockley, R.P.; Trowbridge, R.L.; Ballard, T.M.; Macadam, A.M. 1992. Nutrient management in interior forest types. In: Chappell, H.N.; Weetman, G.F.; Miller, R.E., eds. Forest fertilization: sustaining and improving nutrition and growth of western forests. Contribution No. 73. Seattle, WA: University of Washington, College of Forest Resources: 43-64.

Brodie, L.C.; Harrington, C.A. 2020. Guide to variable-density thinning using skips and gaps. Gen. Tech. Rep. PNW-GTR-989. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 37 p. https://www.fs.usda.gov/treesearch/pubs/60596

Brown, T.C. 1987. Production and cost of scenic beauty: examples for a ponderosa pine forest. Forest Science. 33(2): 394-410. doi:10.1093/forestscience/33.2.394

Brown, R. 2002. Thinning, fire and forest restoration: A science-based approach for national forests in the interior northwest. Washington, DC: Defenders of Wildlife. 40 p. thinning-fire-and-forest-restoration-science-based-approach-national-forests-interior

Brown, R. 2008. The implications of climate change for conservation, restoration, and management of national forest lands. [Eugene, OR]: University of Oregon. 32 p. Brown 2008

Brown, S.J.M. 2012. The Soda Bear Project and the Blue Mountains Forest Partners/USDA Forest Service collaboration. Journal of Forestry. 110(8): 446-447. doi:10.5849/jof.12-078

Brown, P.M.; Cook, B. 2006. Early settlement forest structure in Black Hills ponderosa pine forests. Forest Ecology and Management. 223(1-3): 284-290. doi:10.1016/j.foreco.2005.11.008

Brown, T.C.; Daniel, T.C. 1984. Modeling forest scenic beauty: concepts and application to ponderosa pine. Res. Pap. RM-256. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 35 p. https://www.fs.usda.gov/treesearch/pubs/6264

Brown, P.M.; Sieg, C.H. 1996. Fire history in interior ponderosa pine communities of the Black Hills, South Dakota, USA. International Journal of Wildland Fire. 6(3): 97-105. doi:10.1071/WF9960097

Brown, J.K.; Smith, J.K., eds. 2000. Wildland fire in ecosystems: Effects of fire on flora. Gen.

Tech. Rep. RMRS-GTR-42-volume 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 p. http://www.treesearch.fs.fed.us/pubs/4554

Brown, J.K.; Marsden, M.A.; Ryan, K.C.; Reinhardt, E.D. 1985. Predicting duff and woody fuel consumed by prescribed fire in the northern Rocky Mountains. Res. Paper INT-337. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 23 p. https://www.fs.usda.gov/treesearch/pubs/32531

Brown, J.K.; Reinhardt, E.D.; Fischer, W.C. 1991. Predicting duff and woody fuel consumption in northern Idaho prescribed fires. Forest Science. 37(6): 1550-1566. doi:10.1093/forestscience/37.6.1550

Brown, J.K.; Arno, S.F.; Barrett, S.W.; Menakis, J.P. 1994. Comparing the prescribed natural fire program with presettlement fires in the Selway-Bitterroot Wilderness. International Journal of Wildland Fire. 4(3): 157-168. doi:10.1071/WF9940157

Brown, P.M.; Kaufmann, M.R.; Shepperd, W.D. 1999. Long-term, landscape patterns of past fire events in a montane ponderosa pine forest of central Colorado. Landscape Ecology. 14(6): 513-532. doi:10.1023/A:1008137005355

Brown, P.M.; Ryan, M.G.; Andrews, T.G. 2000. Historical surface fire frequency in ponderosa pine stands in research natural areas, central Rocky Mountains and Black Hills, USA. Natural Areas Journal. 20(2): 133-139. www.jstor.org/stable/43911898

Brown, J.K.; Reinhardt, E.D.; Kramer, K.A. 2003. Coarse woody debris: Managing benefits and fire hazard in the recovering forest. Gen. Tech. Rep. RMRS-GTR-105. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 16 p. http://www.treesearch.fs.fed.us/pubs/5585

Brown, R.T.; Agee, J.K.; Franklin, J.F. 2004. Forest restoration and fire: Principles in the context of place. Conservation Biology. 18(4): 903-912. doi:10.1111/j.1523-1739.2004.521_1.x

Brown, P.M.; Battaglia, M.A.; Fornwalt, P.J.; Gannon, B.; Huckaby, L.S.; Julian, C.; Cheng, A.S. 2015. Historical (1860) forest structure in ponderosa pine forests of the northern Front Range, Colorado. Canadian Journal of Forest Research. 45(11): 1462-1473. doi:10.1139/cjfr-2014-0387

Brown, P.M.; Gentry, C.; Yao, Q. 2019a. Historical and current fire regimes in ponderosa pine forests at Zion National Park, Utah: Restoration of pattern and process after a century of fire exclusion. Forest Ecology and Management. 445: 1-12. doi:10.1016/j.foreco.2019.04.058

Brown, G.W.; Murphy, A.; Fanson, B.; Tolsma, A. 2019b. The influence of different restoration thinning treatments on tree growth in a depleted forest system. Forest Ecology and Management. 437: 10-16. doi:10.1016/j.foreco.2019.01.022

Bruce, D. 1923. Light burning--Report of the California Forestry Committee. Journal of Forestry. 21(2): 129-133. doi:10.1093/jof/21.2.129

Brundtland, G.H. 1987. Our common future: From one earth to one world. New York: United Nations, World Commission on Environment and Development. 300 p. isbn:9780192820808

Buchanan, J.B.; Rogers, R.E.; Pierce, D.J.; Jacobson, J.E. 2003. Nest-site habitat use by white-headed woodpeckers in the eastern Cascade Mountains, Washington. Northwestern Naturalist. 84(3): 119-128. doi:10.2307/3536537

Bull, E.L.; Parks, C.G.; Torgersen, T.R. 1997. Trees and logs important to wildlife in the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-391. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 55 p. https://www.fs.usda.gov/treesearch/pubs/3051

Buma, B.; Wessman, C.A. 2013. Forest resilience, climate change, and opportunities for adaptation: A specific case of a general problem. Forest Ecology and Management. 306: 216-225. doi:10.1016/j.foreco.2013.06.044

Bunnell, F.L.; Kremsater, L.L. 1990. Sustaining wildlife in managed forests. Northwest Environmental Journal. 6(2): 243-269.

Buotte, P.C.; Law, B.E.; Ripple, W.J.; Berner, L.T. 2020. Carbon sequestration and biodiversity co-benefits of preserving forests in the western United States. Ecological Applications. 30(2): e02039 (11 p). doi:10.1002/eap.2039

Bureau of the Census. 1895. Report on the statistics of agriculture in the United States at the eleventh census: 1890. Washington, DC: U.S. Depart. of the Interior, Census Office.

Bureau of the Census. 1902. Twelfth census of the United States, taken in the year 1900; agriculture; part I: Farms, live stock, and animal products. Volume V. Washington, DC: U.S. Depart. of the Interior, Census Office.

Bureau of the Census. 1913. Thirteenth census of the United States, taken in the year 1910; volume VII; agriculture, 1909 and 1910. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1922. Fourteenth census of the United States taken in the year 1920; volume VI, part 3, agriculture. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1927. United States census of agriculture; the western states. Part III. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1932. Fifteenth census of the United States; agriculture; the western states. Volume I, Part 32. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1942. Sixteenth census of the United States; agriculture; first and second series states reports; statistics for counties. Volume I, Part 6. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1946. United States census of agriculture; Washington and Oregon; statistics for counties. Volume I, Part 32. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1952. 1950 United States census of agriculture; Washington and Oregon; counties and state economic areas. Volume 1, Part 32. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1956. United States census of agriculture: 1954; counties and state economic areas; Washington and Oregon. Volume 1, Part 32. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Bureau of the Census. 1961. U.S. census of agriculture: 1959; counties; Washington and Oregon. Volume 1, Part 46 and Part 47. Washington, DC: U.S. Depart. of Commerce, Bureau of the Census.

Burgoyne, T.A.; DeLuca, T.H. 2009. Short-term effects of forest restoration management on non-symbiotic nitrogen-fixation in western Montana. Forest Ecology and Management. 258(7): 1369-1375. doi:10.1016/j.foreco.2009.06.048

Burkhardt, J.W.; Tisdale, E.W. 1976. Causes of juniper invasion in southwestern Idaho. Ecology. 57(3): 472-484. doi:10.2307/1936432

Burnett, J.D.; Anderson, P.D. 2019. Using generalized additive models for interpolating microclimate in dry-site ponderosa pine forests. Agricultural and Forest Meteorology. 279: 107668 (11 p). doi:10.1016/j.agrformet.2019.107668

Burns, M.; Cheng, A.S. 2007. Framing the need for active management for wildfire mitigation and forest restoration. Society and Natural Resources. 20(3): 245-259. doi:10.1080/08941920601117348

Burns, R.M.; Honkala, B.H. 1990a. Silvics of North America; Volume 1, conifers. Agricul. Handb. 654. Washington, DC: USDA Forest Service. 675 p. https://www.treesearch.fs.fed.us/pubs/1547

Burns, R.M.; Honkala, B.H. 1990b. Silvics of North America; Volume 2, hardwoods. Agricul. Handb. 654. Washington, DC: USDA Forest Service. 877 p. https://www.treesearch.fs.fed.us/pubs/1548

Burns, L.K.L.; Loeb, S.C.; Bridges, W.C. 2019. Effects of fire and its severity on occupancy of bats in mixed pine-oak forests. Forest Ecology and Management. 446: 151-163. doi:10.1016/j.foreco.2019.05.024

Busse, M. 2010. Site quality changes in response to slash retention and prescribed fire in thinned ponderosa pine forests. In: Jain, T.B.; Graham, R.T.; Sandquist, J., tech. eds. Integrated management of carbon sequestration and biomass utilization opportunities in a changing climate: proceedings of the 2009 National Silviculture Workshop. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 239-250. http://www.treesearch.fs.fed.us/pubs/37332

Busse, M.D.; Cochran, P.H.; Barrett, J.W. 1996. Changes in ponderosa pine site productivity following removal of understory vegetation. Soil Science Society of America Journal. 60(6): 1614-1621. doi:10.2136/sssaj1996.03615995006000060004x

Busse, M.D.; Simon, S.A.; Riegel, G.M. 2000. Tree-growth and understory responses to low-severity prescribed burning in thinned *Pinus ponderosa* forests of central Oregon. Forest Science. 46(2): 258-268. doi:10.1093/forestscience/46.2.258

Busse, M.D.; Cochran, P.H.; Hopkins, W.E.; Johnson, W.H.; Riegel, G.M.; Fiddler, G.O.; Ratcliff, A.W.; Shestak, C.J. 2009. Developing resilient ponderosa pine forests with mechanical thinning and prescribed fire in central Oregon's pumice region. Canadian Journal of Forest Research. 39(6): 1171-1185. doi:10.1139/X09-044

Callaham, R.Z. 2013. *Pinus ponderosa*: a taxonomic review with five subspecies in the United States. Res. Pap. PSW-RP-264. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 52 p. http://www.treesearch.fs.fed.us/pubs/44726

Callaway, R.M.; DeLucia, E.H.; Schlesinger, W.H. 1994. Biomass allocation of montane and desert ponderosa pine: An analog for response to climate change. Ecology. 75(5): 1474-1481. doi:10.2307/1937470

Callaway, R.M.; DeLucia, E.H.; Moore, D.; Nowak, R.; Schlesinger, W.H. 1996. Competition and facilitation: contrasting effects of *Artemisia tridentata* on desert vs. montane pines. Ecology. 77(7): 2130-2141. doi:10.2307/2265707

Camp, A.; Oliver, C.; Hessburg, P.; Everett, R. 1997. Predicting late-successional fire refugia predating European settlement in the Wenatchee Mountains. Forest Ecology and Management. 95(1): 63-77. doi:10.1016/S0378-1127(97)00006-6

Campbell, E.T.; Brown, M.T. 2012. Environmental accounting of natural capital and ecosystem services for the US National Forest System. Environment, Development and Sustainability.

14(5): 691-724. doi:10.1007/s10668-012-9348-6

Campbell, J.; Alberti, G.; Martin, J.; Law, B.E. 2009. Carbon dynamics of a ponderosa pine plantation following a thinning treatment in the northern Sierra Nevada. Forest Ecology and Management. 257(2): 453-463. doi:10.1016/j.foreco.2008.09.021

Campbell, J.L.; Harmon, M.E.; Mitchell, S.R. 2012. Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? Frontiers in Ecology and the Environment. 10(2): 83-90. doi:10.1890/110057

Cannon, J.B.; Barrett, K.J.; Gannon, B.M.; Addington, R.N.; Battaglia, M.A.; Fornwalt, P.J.; Aplet, G.H.; Cheng, A.S.; Underhill, J.L.; Briggs, J.S.; Brown, P.M. 2018. Collaborative restoration effects on forest structure in ponderosa pine-dominated forests of Colorado. Forest Ecology and Management. 424: 191-204. doi:10.1016/j.foreco.2018.04.026

Cansler, C.A.; McKenzie, D. 2014. Climate, fire size, and biophysical setting control fire severity and spatial pattern in the northern Cascade Range, USA. Ecological Applications. 24(5): 1037-1056. doi:10.1890/13-1077.1

Caon, L.; Vallejo, V.R.; Ritsema, C.J.; Geissen, V. 2014. Effects of wildfire on soil nutrients in Mediterranean ecosystems. Earth-Science Reviews. 139: 47-58. doi:10.1016/j.earscirev.2014.09.001

Caraher, D.L. 1978. The spread of western juniper in central Oregon. In: Martin, R.E.; Dealy, J.E.; Caraher, D.L., eds. Proceedings of the western juniper ecology and management workshop. Gen. Tech. Rep. PNW-74. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station: 3-7. https://www.fs.usda.gov/treesearch/pubs/25144

Caraher, D.L.; Henshaw, J.; Hall, F.; Knapp, W.H.; McCammon, B.P.; Nesbitt, J.; Pedersen, R.J.; Regenovitch, I.; Tietz, C. 1992. Restoring ecosystems in the Blue Mountains: A report to the Regional Forester and the Forest Supervisors of the Blue Mountain forests. Portland, OR: USDA Forest Service, Pacific Northwest Region. 14 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015660.pdf

Carle, D. 2002. Burning questions: America's fight with nature's fire. Westport, CT: Praeger Publishers. 298 p. isbn:0-275-97371-9

Carlson, C.E.; Lotan, J.E. 1988. Using stand culture techniques against defoliating insects. In: Schmidt, W.C., comp. Proceedings–future forests of the mountain west: a stand culture symposium. Gen. Tech. Rep. INT-243. Ogden, UT: USDA Forest Service, Intermountain Research Station: 275-277. https://archive.org/download/CAT88897341/CAT88897341.pdf

Carlson, C.E.; Wulf, N.W. 1989. Silvicultural strategies to reduce stand and forest susceptibility to the western spruce budworm. Agric. Hand. 676. Washington, DC: USDA Forest Service, Cooperative State Research Service. 31 p. https://naldc.nal.usda.gov/download/CAT89916903/PDF

Carlson, C.E.; Pfister, R.D.; Theroux, L.J.; Fiedler, C.E. 1985. Release of a thinned budworm-infested Douglas-fir/ponderosa pine stand. Res. Pap. INT-349. Ogden, UT: USDA Forest Service, Intermountain Research Station. 8 p. https://archive.org/download/releaseofthinned349carl/releaseofthinned349carl.pdf

Carlton, D.W.; Pickford, S.G. 1982. Fuel bed changes with aging of slash from ponderosa pine thinnings. Journal of Forestry. 80(2): 91-93. doi:10.1093/jof/80.2.91

Carnwath, G.C.; Peterson, D.W.; Nelson, C.R. 2012. Effect of crown class and habitat type on climate-growth relationships of ponderosa pine and Douglas-fir. Forest Ecology and Management. 285: 44-52. doi:10.1016/j.foreco.2012.07.037

Carr, C.A.; Krueger, W.C. 2011. Understory vegetation and ponderosa pine abundance in eastern Oregon. Rangeland Ecology and Management. 64(5): 533-542. doi:10.2111/REM-D-09-00005.1

Carr, C.A.; Krueger, W.C. 2012. The role of the seed bank in recovery of understory species in an eastern Oregon ponderosa pine forest. Northwest Science. 86(3): 168-178. doi:10.3955/046.086.0302

Carr, C.A.; Krueger, W.C. 2017. Resource limitations influence growth and vigor of Idaho fescue, a common understory species in Pacific Northwest ponderosa pine forests. Forests. 8(1): 6 (9 p). doi:10.3390/f8010006

Carroll, M.S.; Blatner, K.A.; Alt, F.J.; Schuster, E.G.; Findley, A.J. 2000. Adaptation strategies of displaced Idaho woods workers: Results of a longitudinal panel study. Society and Natural Resources. 13(2): 95-113. doi:10.1080/089419200279135

Case, R.L.; Kauffman, J.B. 1997. Wild ungulate influences on the recovery of willows, black cottonwood and thin-leaf alder following cessation of cattle grazing in northeastern Oregon. Northwest Science. 71(2): 115-126. http://hdl.handle.net/2376/1249

Casey, D.; Altman, B.; Stringer, D.; Thomas, C. [Date unknown]. Land manager's guide to cavity-nesting bird habitat and populations in ponderosa pine forests of the Pacific Northwest. [Place of publication unknown]: American Bird Conservancy. 32 p. Ponderosa Pine bird guide

Casey, D.; Altman, B.; Stringer, D. [Date unknown]. Snags, bark beetles, and cavity-nesting birds: Conservation and management in ponderosa pine forests of the Pacific Northwest. [Place of publication unknown]: American Bird Conservancy. 16 p. Cavity-nester-booklet

Cassell, B.A.; Scheller, R.M.; Lucash, M.S.; Hurteau, M.D.; Loudermilk, E.L. 2019. Widespread severe wildfires under climate change lead to increased forest homogeneity in dry mixed-conifer forests. Ecosphere. 10(11): e02934 (20 p). doi:10.1002/ecs2.2934

Chambers, C.L.; Mast, J.N. 2005. Ponderosa pine snag dynamics and cavity excavation following wildfire in northern Arizona. Forest Ecology and Management. 216(1-3): 227-240. doi:10.1016/j.foreco.2005.05.033

Chambers, C.L.; Mast, J.N. 2014. Snag dynamics and cavity excavation after bark beetle outbreaks in southwestern ponderosa pine forests. Forest Science. 60(4): 713-723. doi:10.5849/forsci.13-018

Chambers, M.E.; Fornwalt, P.J.; Malone, S.L.; Battaglia, M.A. 2016. Patterns of conifer regeneration following high severity wildfire in ponderosa pine-dominated forests of the Colorado Front Range. Forest Ecology and Management. 378: 57-67. doi:10.1016/j.foreco.2016.07.001

Chambers, J.C.; Allen, C.R.; Cushman, S.A. 2020. Operationalizing the concepts of resilience and resistance for managing ecosystems and species at risk. Frontiers in Ecology and Evolution. Lausanne, Switzerland: Frontiers Media SA. 223 p. doi:10.3389/978-2-88963-867-3

Chapin, F.S. III; Torn, M.S.; Tateno, M. 1996. Principles of ecosystem sustainability. American Naturalist. 148(6): 1016-1037. doi:10.2307/2463560

Chapin, F.S.; Pickett, S.T.A.; Power, M.E.; Jackson, R.B.; Carter, D.M.; Duke, C. 2011. Earth stewardship: a strategy for social–ecological transformation to reverse planetary degradation. Journal of Environmental Studies and Sciences. 1(1): 44-53. doi:10.1007/s13412-011-0010-7

Chatterjee, A.; Vance, G.F.; Tinker, D.B. 2009. Carbon pools of managed and unmanaged stands of ponderosa and lodgepole pine forests in Wyoming. Canadian Journal of Forest Research.

39(10): 1893-1900. doi:10.1139/X09-112

Childs, T.W. 1968a. Comandra rust damage to ponderosa pine in Oregon and Washington. Misc. Pub. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p. Comandra_Rust_Damage_to_Ponderosa_Pine

Childs, T.W. 1968b. Elytroderma disease of ponderosa pine in the Pacific Northwest. Res. Pap. PNW-69. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 46 p. https://archive.org/download/CAT92272713/CAT92272713.pdf

Childs, T.W.; Edgren, J.W. 1967. Dwarf mistletoe effects on ponderosa pine growth and trunk form. Forest Science. 13(2): 167-174. doi:10.1093/forestscience/13.2.167

Chiono, L.A.; O'Hara, K.L.; De Lasaux, M.J.; Nader, G.A.; Stephens, S.L. 2012. Development of vegetation and surface fuels following fire hazard reduction treatment. Forests. 3(3): 700-722. doi:10.3390/f3030700

Chmura, D.J.; Anderson, P.D.; Howe, G.T.; Harrington, C.A.; Halofsky, J.E.; Peterson, D.L.; Shaw, D.C.; St.Clair, B.J. 2011. Forest responses to climate change in the northwestern United States: Ecophysiological foundations for adaptive management. Forest Ecology and Management. 261(7): 1121-1142. doi:10.1016/j.foreco.2010.12.040

Chojnacky, D.C.; Bentz, B.J.; Logan, J.A. 2000. Mountain pine beetle attack in ponderosa pine: Comparing methods for rating susceptibility. Res. Pap. RMRS-RP-26. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 10 p. https://www.fs.usda.gov/treesearch/pubs/4621

Choromanska, U.; DeLuca, T.H. 2001. Prescribed fire alters the impact of wildfire on soil biochemical properties in a ponderosa pine forest. Soil Science Society of America Journal. 65(1): 232-238. doi:10.2136/sssaj2001.651232x

Christensen, N.L.; Bartuska, A.M.; Brown, J.H.; Carpenter, S.; D'Antonio, C.; Francis, R.; Franklin, J.F.; MacMahon, J.A.; Noss, R.F.; Parsons, D.J.; Peterson, C.H.; Turner, M.G.; Woodmansee, R.G. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications. 6(3): 665-691. doi:10.2307/2269460

Christensen, G.A.; Dunham, P.; Powell, D.C.; Hiserote, B. 2007. Forest resources of the Umatilla National Forest. Res. Bull. PNW-RB-253. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 38 p. http://www.treesearch.fs.fed.us/pubs/27656

Christiansen, E.; Waring, R.H.; Berryman, A.A. 1987. Resistance of conifers to bark beetle attack: Searching for general relationships. Forest Ecology and Management. 22(1-2): 89-106. doi:10.1016/0378-1127(87)90098-3

Chung, W.; Jones, G.; Krueger, K.; Bramel, J.; Contreras, M. 2013. Optimizing fuel treatments over time and space. International Journal of Wildland Fire. 22(8): 1118-1133. doi:10.1071/WF12138

Church, J.E., Jr. 1912. The conservation of snow: Its dependence on mountains and forests. Official Bulletin of the International Irrigation Congress. 1(6): 45-52. Official_Bulletin

Churchill, D.J.; Larson, A.J.; Dahlgreen, M.C.; Franklin, J.F.; Hessburg, P.F.; Lutz, J.A. 2013a. Restoring forest resilience: From reference spatial patterns to silvicultural prescriptions and monitoring. Forest Ecology and Management. 291: 442-457. doi:10.1016/j.foreco.2012.11.007

Churchill, D.J.; Jeronimo, S.; Larson, A.J.; Fischer, P.; Dalhgreen, M.C.; Franklin, J.F. 2016. The

ICO approach to quantifying and restoring forest spatial pattern: Implementation guide (version 3.1). Vashon, WA: Stewardship Forestry and Science. 68 p. ICO-Manager-Guide-version-3-1

Churchill, D.J.; Carnwath, G.C.; Larson, A.J.; Jeronimo, S.A. 2017. Historical forest structure, composition, and spatial pattern in dry conifer forests of the western Blue Mountains, Oregon. Gen. Tech. Rep. PNW-GTR-956. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 93 p. https://www.fs.usda.gov/treesearch/pubs/55418

Clark, J.S. 1991. Disturbance and tree life history on the shifting mosaic landscape. Ecology. 72(3): 1102-1118. doi:10.2307/1940609

Clark, L.R.; Sampson, R.N. 1995. Forest ecosystem health in the inland west: a science and policy reader. Washington, DC: American Forests, Forest Policy Center. 37 p.

Clark, R.N.; Meidinger, E.E.; Miller, G.; Rayner, J.; Layseca, M.; Monreal, S.; Fernandez, J.; Shannon, M.A. 1998. Integrating science and policy in natural resource management: lessons and opportunities from North America. Gen. Tech. Rep. PNW-GTR-441. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 22 p. http://www.treesearch.fs.fed.us/pubs/2998

Clarke, S.E.; Bryce, S.A., eds. 1997. Hierarchical subdivisions of the Columbia Plateau and Blue Mountain ecoregions, Oregon and Washington. Gen. Tech. Rep. PNW-GTR-395. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 114 p. https://www.fs.usda.gov/treesearch/pubs/7595

Clary, W.P.; Ffolliott, P.F. 1966. Differences in herbage-timber relationships between thinned and unthinned ponderosa pine stands. Res. Note RM-74. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/CAT10231796/CAT10231796.pdf

Clary, W.P.; Kruse, W.H.; Larson, F.R. 1975. Cattle grazing and wood production with different basal areas of ponderosa pine. Journal of Range Management. 28(6): 434-437. https://journals.uair.arizona.edu/index.php/jrm/article/download/6505/6115

Clausnitzer, R.R. 1993. The grand fir series of northeastern Oregon and southeastern Washington: Successional stages and management guide. Tech. Pub. R6-ECO-TP-050-93. USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 193 p. https://ir.library.oregonstate.edu/downloads/8s45qb336

Clayton, J.L.; Kennedy, D.A. 1980. A comparison of the nutrient content of Rocky Mountain Douglas-fir and ponderosa pine trees. Res. Note INT-281. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 13 p. A_Comparison_of_the_Nutrient_Content_of

Cleland, D.T.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G.; King, T.; Russell, W.E. 1997. National hierarchical framework of ecological units. In: Boyce, M.S.; Haney, A., eds. Ecosystem management: applications for sustainable forest and wildlife resources. New Haven, CT: Yale University Press: 181-200. isbn:0-300-06902-2

Cliff, E.P. 1939. Relationship between elk and mule deer in the Blue Mountains of Oregon. Transactions of the North American Wildlife Conference. 4: 560-569.

Climate Central. 2012. The age of western wildfires. Princeton, NJ: Climate Central (www.climatecentral.org). 18 p. http://www.climatecentral.org/news/report-the-age-of-western-wildfires-14873

Clyatt, K.A.; Crotteau, J.S.; Schaedel, M.S.; Wiggins, H.L.; Kelley, H.; Churchill, D.J.; Larson, A.J.

2016. Historical spatial patterns and contemporary tree mortality in dry mixed-conifer forests. Forest Ecology and Management. 361: 23-37. doi:10.1016/j.foreco.2015.10.049

Clyatt, K.A.; Keyes, C.R.; Hood, S.M. 2017. Long-term effects of fuel treatments on aboveground biomass accumulation in ponderosa pine forests of the northern Rocky Mountains. Forest Ecology and Management. 400: 587-599. doi:10.1016/j.foreco.2017.06.021

Coates, K.D.; Burton, P.J. 1997. A gap-based approach for development of silvicultural systems to address ecosystem management objectives. Forest Ecology and Management. 99(3): 337-354. doi:10.1016/S0378-1127(97)00113-8

Cobb, D.F.; O'Hara, K.L.; Oliver, C.D. 1993. Effects of variations in stand structure on development of mixed-species stands in eastern Washington. Canadian Journal of Forest Research. 23(3): 545-552. doi:10.1139/x93-072

Cochran, P.H. 1973. Response of individual ponderosa pine trees to fertilization. Res. Note PNW-206. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 15 p. Response_of_Individual_Ponderosa_Pine_Tr

Cochran, P.H. 1979. Response of thinned ponderosa pine to fertilization. Res. Note PNW-339. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p. https://archive.org/download/responseofthinne339coch/responseofthinne339coch.pdf

Cochran, P.H. 1984. Should ponderosa pine be planted on lodgepole pine sites? Res. Note PNW-419. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p. https://www.fs.usda.gov/treesearch/pubs/26800

Cochran, P.H. 1992. Stocking levels and underlying assumptions for uneven-aged ponderosa pine stands. Res. Note PNW-RN-509. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 10 p. http://www.treesearch.fs.fed.us/pubs/25110

Cochran, P.H. 1998. Examples of mortality and reduced annual increment of white fir induced by drought, insects, and disease at different stand densities. Res. Note PNW-RN-525. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 19 p. http://www.treesearch.fs.fed.us/pubs/3036

Cochran, P.H.; Barrett, J.W. 1993. Long-term response of planted ponderosa pine to thinning in Oregon's Blue Mountains. Western Journal of Applied Forestry. 8(4): 126-132. doi:10.1093/wjaf/8.4.126

Cochran, P.H.; Barrett, J.W. 1995. Growth and mortality of ponderosa pine poles thinned to various densities in the Blue Mountains of Oregon. Res. Pap. PNW-RP-483. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 27 p. https://www.fs.usda.gov/treesearch/pubs/20593

Cochran, P.H.; Barrett, J.W. 1998. Thirty-five-year growth of thinned and unthinned ponderosa pine in the Methow Valley of northern Washington. Res. Pap. PNW-RP-502. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 24 p. https://www.fs.usda.gov/treesearch/pubs/2881

Cochran, P.H.; Barrett, J.W. 1999a. Growth of ponderosa pine thinned to different stocking levels in central Oregon: 30-year results. Res. Pap. PNW-RP-508. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 27 p. https://www.fs.usda.gov/treesearch/pubs/2904

Cochran, P.H.; Barrett, J.W. 1999b. Thirty-five-year growth of ponderosa pine saplings in response to thinning and understory removal. Res. Pap. PNW-RP-512. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 28 p.

https://www.fs.usda.gov/treesearch/pubs/2908

Cochran, P.H.; Berntsen, C.M. 1973. Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures. Forest Science. 19(4): 272-280. doi:10.1093/forestscience/19.4.272

Cochran, P.H.; Brock, T. 1985. Soil compaction and initial height growth of planted ponderosa pine. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 4 p. http://www.treesearch.fs.fed.us/pubs/26845

Cochran, P.H.; Hopkins, W.E. 1991. Does fire exclusion increase productivity of ponderosa pine? In: Harvey, A.E.; Neuenschwander, L.F., comps. Proceedings–management and productivity of western-montane forest soils. Gen. Tech. Rep. INT-280. Ogden, UT: USDA Forest Service, Intermountain Research Station: 224-228. http://www.treesearch.fs.fed.us/pubs/33908

Cochran, P.H.; Jennings, J.W.; Youngberg, C.T. 1984. Biomass estimators for thinned second-growth ponderosa pine trees. Res. Note PNW-415. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 6 p. http://www.treesearch.fs.fed.us/pubs/26783

Cochran, P.H.; Geist, J.M.; Clemens, D.L.; Clausnitzer, R.R.; Powell, D.C. 1994. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington. Research Note PNW-RN-513. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 21 p. http://www.treesearch.fs.fed.us/pubs/25113

Cohen, J. 2008. The wildland-urban interface fire problem: A consequence of the fire exclusion paradigm. Forest History Today. Fall: 20-26. http://www.foresthistory.org/Publications/FHT/FHTFall2008/Cohen.pdf

Cole, D.N. 1981. Vegetational changes associated with recreational use and fire suppression in the Eagle Cap Wilderness, Oregon: some management implications. Biological Conservation. 20(4): 247-270. doi:10.1016/0006-3207(81)90013-6

Collins, T.W. 2009. Influences on wildfire hazard exposure in Arizona's high country. Society and Natural Resources. 22(3): 211-229. doi:10.1080/08941920801905336

Collins, B.M.; Omi, P.N.; Chapman, P.L. 2006. Regional relationships between climate and wildfire-burned area in the interior West, USA. Canadian Journal of Forest Research. 36(3): 699-709. doi:10.1139/x05-264

Collins, B.M.; Moghaddas, J.J.; Stephens, S.L. 2007. Initial changes in forest structure and understory plant communities following fuel reduction activities in a Sierra Nevada mixed conifer forest. Forest Ecology and Management. 239(1-3): 102-111. doi:10.1016/j.foreco.2006.11.013

Collins, B.M.; Stephens, S.L.; Moghaddas, J.J.; Battles, J. 2010. Challenges and approaches in planning fuel treatments across fire-excluded forested landscapes. Journal of Forestry. 108(1): 24-31. doi:10.1093/jof/108.1.24

Collins, B.M.; Everett, R.G.; Stephens, S.L. 2011a. Impacts of fire exclusion and recent managed fire on forest structure in old growth Sierra Nevada mixed-conifer forests. Ecosphere. 2(4): art51 (13 p). doi:10.1890/ES11-00026.1

Collins, B.M.; Stephens, S.L.; Roller, G.B.; Battles, J.J. 2011b. Simulating fire and forest dynamics for a landscape fuel treatment project in the Sierra Nevada. Forest Science. 57(2): 77-88. doi:10.1093/forestscience/57.2.77

Collins, B.M.; Das, A.J.; Battles, J.J.; Fry, D.L.; Krasnow, K.D.; Stephens, S.L. 2014. Beyond reducing fire hazard: fuel treatment impacts on overstory tree survival. Ecological Applications. 24(8): 1879-1886. doi:10.1890/14-0971.1

Collins, B.M.; Lydersen, J.M.; Fry, D.L.; Wilkin, K.; Moody, T.; Stephens, S.L. 2016. Variability in vegetation and surface fuels across mixed-conifer-dominated landscapes with over 40 years of natural fire. Forest Ecology and Management. 381: 74-83. doi:10.1016/j.foreco.2016.09.010

Collins, B.M.; Fry, D.L.; Lydersen, J.M.; Everett, R.; Stephens, S.L. 2017. Impacts of different land management histories on forest change. Ecological Applications. 27(8): 2475-2486. doi:10.1002/eap.1622

Coman, W.E. 1911. Did the Indian protect the forest? Pacific Monthly. 26(3): 300-306.

Conklin, D.A.; Armstrong, W.A. 2005. Effects of three prescribed fires on dwarf mistletoe infection in southwestern ponderosa pine. R3-01-02. Albuquerque, NM: USDA Forest Service, Southwestern Region, Forestry and Forest Health. 18 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5238544.pdf

Connaughton, C.A. 1935. Growth in virgin ponderosa pine stands in central Idaho. Journal of Forestry. 33(1): 73-79. doi:10.1093/jof/33.1.73

Connaughton, C.A. 1936. Fire damage in the ponderosa pine type in Idaho. Journal of Forestry. 34(1): 46-51. doi:10.1093/jof/34.1.46

Constable, J.V.H.; Taylor, G.E., Jr.; Laurence, J.A.; Weber, J.A. 1996. Climatic change effects on the physiology and growth of *Pinus ponderosa*: expectations from simulation modeling. Canadian Journal of Forest Research. 26(8): 1315-1325. doi:10.1139/x26-147

Cook, S.F. 1955. The epidemic of 1830-1833 in California and Oregon. University of California Publications in American Archaeology and Ethnology. 43(3): 303-326. Epidemic of 1830-1833 in California and Oregon

Cook, E.R.; Woodhouse, C.A.; Eakin, C.M.; Meko, D.M.; Stahle, D.W. 2004. Long-term aridity changes in the western United States. Science. 306(5698): 1015-1018. doi:10.1126/science.1102586

Coomes, D.A.; Grubb, P.J. 2000. Impacts of root competition in forests and woodlands: a theoretical framework and review of experiments. Ecological Monographs. 70(2): 171-207. doi:10.1890/0012-9615(2000)070[0171:IORCIF]2.0.CO;2

Coop, J.D.; DeLory, T.J.; Downing, W.M.; Haire, S.L.; Krawchuk, M.A.; Miller, C.; Parisien, M.-A.; Walker, R.B. 2019. Contributions of fire refugia to resilient ponderosa pine and dry mixed-conifer forest landscapes. Ecosphere. 10(7): e02809 (24 p). doi:10.1002/ecs2.2809

Cooper, A.W. 1906. Sugar pine and western yellow pine in California. Bull. No. 69. Washington, DC: USDA Forest Service. 42 p. https://archive.org/download/sugarpinewestern00coop/sugarpinewestern00coop.pdf

Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since white settlement. Ecological Monographs. 30(2): 129-164. doi:10.2307/1948549

Cooper, C.F. 1961a. Equations for the description of past growth in even-aged stands of ponderosa pine. Forest Science. 7(1): 72-80. doi:10.1093/forestscience/7.1.72

Cooper, C.F. 1961b. Pattern in ponderosa pine forests. Ecology. 42(3): 493-499. doi:10.2307/1932235

Cooper, C.F. 1961c. The ecology of fire. Scientific American. 204(4): 150-158. doi:10.1038/scientificamerican0461-150

Coops, N.C.; Waring, R.H.; Law, B.E. 2005. Assessing the past and future distribution and productivity of ponderosa pine in the Pacific Northwest using a process model, 3-PG. Ecological Modelling. 183(1): 107-124. doi:10.1016/j.ecolmodel.2004.08.002

Corlett, R.T. 2015. The Anthropocene concept in ecology and conservation. Trends in Ecology and Evolution. 30(1): 36-41. doi:10.1016/j.tree.2014.10.007

Costello, S.L.; Negrón, J.F.; Jacobi, W.R. 2011. Wood-boring insect abundance in fire-injured ponderosa pine. Agricultural and Forest Entomology. 13(4): 373-381. doi:10.1111/j.1461-9563.2011.00531.x

Coville, F.V. 1898. Forest growth and sheep grazing in the Cascade Mountains of Oregon. Bulletin No. 15. Washington, DC: USDA Division of Forestry. 54 p. https://archive.org/download/forestgrowthshee15covi/forestgrowthshee15covi.pdf

Covington, W.W. 2000a. Helping western forests heal. Nature. 408(6809): 135-136. doi:10.1038/35041641

Covington, W.W. 2000b. Perspective: Prescribed fire is not the issue. Journal of Forestry. 98(8): 48. doi:10.1093/jof/98.8.48

Covington, W.W. 2003. Restoring ecosystem health in frequent-fire forests of the American West. Ecological Restoration. 21(1): 7-11. doi:10.3368/er.21.1.7

Covington, W.W.; Moore, M.M. 1994a. Postsettlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry. 2(1-2): 153-181. doi:10.1300/J091v02n01_07

Covington, W.W.; Moore, M.M. 1994b. Southwestern ponderosa forest structure: Changes since Euro-American settlement. Journal of Forestry. 92(1): 39-47. doi:10.1093/jof/92.1.39

Covington, W.W.; Sackett, S.S. 1984. The effect of a prescribed burn in southwestern ponderosa pine on organic matter and nutrients in woody debris and forest floor. Forest Science. 30(1): 183-192. doi:10.1093/forestscience/30.1.183

Covington, W.W.; Sackett, S.S. 1992. Soil mineral nitrogen changes following prescribed burning in ponderosa pine. Forest Ecology and Management. 54(1-4): 175-191. doi:10.1016/0378-1127(92)90011-W

Covington, W.W.; Everett, R.L.; Steele, R.; Irwin, L.L.; Daer, T.A.; Auclair, A.N.D. 1994. Historical and anticipated changes in forest ecosystems of the inland west of the United States. Journal of Sustainable Forestry. 2(1/2): 13-63. doi:10.1300/J091v02n01_02

Covington, W.W.; Fulé, P.Z.; Moore, M.M.; Hart, S.C.; Kolb, T.E.; Mast, J.N.; Sackett, S.S.; Wagner, M.R. 1997. Restoring ecosystem health in ponderosa pine forests of the Southwest. Journal of Forestry. 95(4): 23-29. doi:10.1093/jof/95.4.23

Covington, W.W.; Fule, P.Z.; Hart, S.C.; Weaver, R.P. 2001. Modeling ecological restoration effects on ponderosa pine forest structure. Restoration Ecology. 9(4): 421-431. doi:10.1046/j.1526-100X.2001.94011.x

Cowan, A.D.; Smith, J.E.; Fitzgerald, S.A. 2016. Recovering lost ground: Effects of soil burn intensity on nutrients and ectomycorrhiza communities of ponderosa pine seedlings. Forest Ecology and Management. 378(Supplement C): 160-172. doi:10.1016/j.foreco.2016.07.030

Cowlin, R.W.; Briegleb, P.A.; Moravets, F.L. 1942. Forest resources of the ponderosa pine region of Washington and Oregon. Misc. Pub. No. 490. Washington, DC: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 99 p (and maps). https://archive.org/download/forestresourceso490cowl/forestresourceso490cowl.pdf

Cox, W.T. 1928. When forest fires began. American Forests. 34(8): 477-479.

Cox, G.S.; McConnell, R.C.; Matthew, L.M. 1960. Ponderosa pine productivity in relation to soil and landform in western Montana. Soil Science Society of America Proceedings. 24(2): 139-142. doi:10.2136/sssaj1960.03615995002400020021x

Cram, D.; Saud, P.; Baker, T. 2017. Structure and composition of a dry mixed-conifer forest in absence of contemporary treatments, Southwest, USA. Forests. 8(9): 349. doi:10.3390/f8090349

Crane, M.F.; Fischer, W.C. 1986. Fire ecology of the forest habitat types of central Idaho. Gen. Tech. Rep. INT-218. Ogden, UT: USDA Forest Service, Intermountain Research Station. 86 p. http://www.treesearch.fs.fed.us/pubs/32956

Creed, I.F.; Weber, M.; Accatino, F.; Kreutzweiser, D.P. 2016. Managing forests for water in the Anthropocene--The best kept secret services of forest ecosystems. Forests. 7(3): 60 (24 p). doi:10.3390/f7030060

Crist, M.R.; DeLuca, T.H.; Wilmer, B.; Aplet, G.H. 2009. Restoration of low-elevation dry forests of the northern Rocky Mountains: a holistic approach. Washington, DC: The Wilderness Society. 39 p. Restoration of Low-Elevation Dry Forests of the Northern Rocky Mountains

Cronon, W., ed. 1996. Uncommon ground: rethinking the human place in nature. New York: W.W. Norton & Company. 561 p. isbn:0-393-31511-8

Crotteau, J.S.; Ritchie, M.W. 2014. Long-term stand growth of interior ponderosa pine stands in response to structural modifications and burning treatments in northeastern California. Journal of Forestry. 112(5): 412-423. doi:10.5849/jof.13-090

Crotteau, J.S.; Keyes, C.R.; Hood, S.M.; Larson, A.J. 2020. Vegetation dynamics following compound disturbance in a dry pine forest: fuel treatment then bark beetle outbreak. Ecological Applications. 30(2): e02023 (19 p). doi:10.1002/eap.2023

Crowe, E.A.; Clausnitzer, R.R. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla and Wallowa-Whitman National Forests. Tech. Pap. R6-NR-ECOL-TP-22-97. Baker City, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 299 p. MidMontaneWetlandPlantAssociationsWallowaWhitnf

Cruickshank, M.G.; Morrison, D.J.; Lalumière, A. 2011. Site, plot, and individual tree yield reduction of interior Douglas-fir associated with non-lethal infection by Armillaria root disease in southern British Columbia. Forest Ecology and Management. 261(2): 297-307. doi:10.1016/j.foreco.2010.10.023

Cumming, G.S.; Olsson, P.; Chapin, F.S., III; Holling, C.S. 2013. Resilience, experimentation, and scale mismatches in social-ecological landscapes. Landscape Ecology. 28(6): 1139-1150. doi:10.1007/s10980-012-9725-4

Cunningham, J.B.; Balda, R.P.; Gaud, W.S. 1980. Selection and use of snags by secondary cavity-nesting birds of the ponderosa pine forest. Res. Pap. RM-222. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p. https://www.biodiversitylibrary.org/itempdf/177400

Currie, P.O. 1975. Grazing management of ponderosa pine-bunchgrass ranges of the central Rocky Mountains: the status of our knowledge. Res. Pap. RM-159. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 24 p. https://archive.org/download/CAT92273532/CAT92273532.pdf

Currie, P.O.; Edminster, C.B.; Knott, F.W. 1978. Effects of cattle grazing on ponderosa pine regeneration in central Colorado. Res. Pap. RM-201. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p.

https://archive.org/download/CAT92273419/CAT92273419.pdf

Curtis, J.D. 1964. Roots of a ponderosa pine. Res. Pap. INT-9. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 10 p. https://archive.org/download/rootsofponderosa09curt/rootsofponderosa09curt.pdf

Curtis, J.D.; Wilson, A.K. 1953. Porcupine feeding on ponderosa pine in central Idaho. Journal of Forestry. 51(5): 339-341. doi:10.1093/jof/51.5.339

Curtis, J.D.; Wilson, A.K. 1958. A test of group selection in Idaho ponderosa pine. Journal of Forestry. 56(3): 182-189. doi:10.1093/jof/56.3.182

Curzon, M.T.; Kern, C.C.; Baker, S.C.; Palik, B.J.; D'Amato, A.W. 2020. Retention forestry influences understory diversity and functional identity. Ecological Applications. 30(5): e02097 (14 p). doi:10.1002/eap.2097

Dahms, W.G. 1949. How long do ponderosa pine snags stand? Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 3 p. https://www.fs.usda.gov/treesearch-beta/pubs/25568

Dahms, W.G. 1954. Growth of pruned ponderosa pine. Journal of Forestry. 52(6): 444-447. doi:10.1093/jof/52.6.444

Dahms, W.G. 1960. Long-suppressed ponderosa pine seedlings respond to release. Portland, OR: USDA Forest Service, Pacific Northwest Range and Experiment Station. 3 p. https://www.fs.usda.gov/treesearch-beta/pubs/25842

Dahms, W.G.; Barrett, J.W. 1975. Seed production of central Oregon ponderosa and lodgepole pines. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 13 p. Seed_Production_of_Central_Oregon_Ponder

Daigle, P. 1996. Fire in the dry interior forests of British Columbia. Extension Note 08. Victoria, BC: British Columbia Ministry of Forests, Research Branch. 5 p. https://www.for.gov.bc.ca/hfd/pubs/Docs/En/En08.pdf

Dalrymple, S.E.; Safford, H.D. 2019. Ants, wind, and low litter deposition contribute to the maintenance of fire-protective clearings around Jeffrey pine (Pinus jeffreyi). Forest Ecology and Management. 438: 44-50. doi:10.1016/j.foreco.2019.01.043

Dalton, M.M.; Mote, P.W.; Snover, A.K. 2013. Climate change in the Northwest: Implications for our landscapes, waters, and communities. Washington, DC: Island Press. 230 p. https://islandpress.org/books/climate-change-northwest

Daniel, T.C.; Boster, R.S. 1976. Measuring landscape esthetics: The scenic beauty estimation method. Res. Pap. RM-167. Fort Collins, CO: USDA Forest Service, Rocky Mountain Range and Experiment Station. 66 p. https://www.fs.usda.gov/treesearch/pubs/20911

Daniel, T.W.; Schmidt, J. 1972. Lethal and nonlethal effects of the organic horizons of forested soils on the germination of seeds from several associated conifer species of the Rocky Mountains. Canadian Journal of Forest Research. 2(3): 179-184. doi:10.1139/x72-031

Daniel, T.W.; Helms, J.A.; Baker, F.S. 1979. Principles of silviculture. 2nd edition. New York: McGraw-Hill. 500 p. isbn:0-07-015297-7

Danielson, J.; Sampson, N., chair. 1995. Forest health and fire danger in inland western forests; proceedings of the conference. Spokane, WA. Unnumbered Rep. [Place of publication unknown]: Boise Cascade Corporation. 236 p.

Darlington, H.T. 1915. A study of grazing conditions in the Wenaha National Forest. Bull. No. 122. Pullman, WA: State College of Washington, Agricultural Experiment Station. 18 p.

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015520.pdf

Daubenmire, R.F. 1950. A comparison of season of cambial growth in different geographic races of *Pinus ponderosa*. Botanical Gazette. 112(2): 182-188. http://www.jstor.org/stable/2472784

Daubenmire, R. 1960. A seven-year study of cone production as related to xylem layers and temperature in *Pinus ponderosa*. American Midland Naturalist. 64(1): 187-193. doi:10.2307/2422901

Daubenmire, R. 1961. Vegetative indicators of rate of height growth in ponderosa pine. Forest Science. 7(1): 24-34. doi:10.1093/forestscience/7.1.24

Davis, T.S.; Hofstetter, R.W. 2014. Allometry of phloem thickness and resin flow and their relation to tree chemotype in a southwestern ponderosa pine forest. Forest Science. 60(2): 270-274. doi:10.5849/forsci.12-155

Davis, B.H.; Miller, C.; Parks, S.A. 2010a. Retrospective fire modeling: quantifying the impacts of fire suppression. Gen. Tech. Rep. RMRS-GTR-236WWW. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 40 p. http://www.treesearch.fs.fed.us/pubs/34889

Davis, E.J.; Moseley, C.; Nielsen-Pincus, M., eds. 2010b. The state of the dry forest zone and its communities. Eugene, OR: University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program. 94 p. http://hdl.handle.net/1794/10802

Davis, R.S.; Hood, S.; Bentz, B.J. 2012. Fire-injured ponderosa pine provide a pulsed resource for bark beetles. Canadian Journal of Forest Research. 42(12): 2022-2036. doi:10.1139/x2012-147

Davis, R.; Yang, Z.; Yost, A.; Belongie, C.; Cohen, W. 2017. The normal fire environment—Modeling environmental suitability for large forest wildfires using past, present, and future climate normals. Forest Ecology and Management. 390: 173-186. doi:10.1016/j.foreco.2017.01.027

Davis, K.T.; Higuera, P.E.; Sala, A. 2018. Anticipating fire-mediated impacts of climate change using a demographic framework. Functional Ecology. 32(7): 1729-1745. doi:10.1111/1365-2435.13132

Davis, K.T.; Dobrowski, S.Z.; Higuera, P.E.; Holden, Z.A.; Veblen, T.T.; Rother, M.T.; Parks, S.A.; Sala, A.; Maneta, M.P. 2019. Wildfires and climate change push low-elevation forests across a critical climate threshold for tree regeneration. Proceedings of the National Academy of Sciences. 116(13): 6193-6198. doi:10.1073/pnas.1815107116

DeBell, D.S.; Ralston, C.W. 1970. Release of nitrogen by burning light forest fuels. Soil Science Society of America Proceedings. 34(6): 936-938. doi:10.2136/sssaj1970.03615995003400060033x

DeGomez, T. 2014. Guidelines for thinning ponderosa pine for improved forest health and fire prevention. Publication AZ1397. Tucson, AZ: University of Arizona, College of Agriculture and Life Sciences, Cooperative Extension. 7 p. https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1397-2014.pdf

DeGraaf, R.M.; Healy, W.M. 1993. The myth of nature's constancy – preservation, protection and ecosystem management. In: Transactions of the 58th North American wildlife and natural resources conference. Washington, DC: Wildlife Management Institute: 17-28. https://www.fs.usda.gov/treesearch/pubs/55464

del Campo, A.D.; González-Sanchis, M.; Lidón, A.; Ceacero, C.J.; García-Prats, A. 2018. Rainfall partitioning after thinning in two low-biomass semiarid forests: Impact of meteorological variables and forest structure on the effectiveness of water-oriented treatments. Journal of Hydrology. 565: 74-86. doi:10.1016/j.jhydrol.2018.08.013

del Moral, R. 1972. Diversity patterns in forest vegetation of the Wenatchee Mountains, Washington. Bulletin of the Torrey Botanical Club. 99(2): 57-64. doi:10.2307/2484199

Dell, J.D.; Ward, F.R. 1969. Reducing fire hazard in ponderosa pine thinning slash by mechanical crushing. Res. Paper PSW-57. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 9 p. https://www.fs.usda.gov/treesearch/pubs/28631

Dello, K.; Mote, P., eds. 2010. Oregon climate assessment report. Corvallis, OR: Oregon State University, College of Oceanic and Atmospheric Sciences. 417 p. http://occri.net/ocar

DeLong, S.C.; Tanner, D. 1996. Managing the pattern of forest harvest: lessons from wildfire. Biodiversity and Conservation. 5(10): 1191-1205. doi:10.1007/BF00051571

DeLuca, T.H.; Zouhar, K.L. 2000. Effects of selection harvest and prescribed fire on the soil nitrogen status of ponderosa pine forests. Forest Ecology and Management. 138(1-3): 263-271. doi:10.1016/S0378-1127(00)00401-1

DeLuca, T.H.; MacKenzie, M.D.; Gundale, M.J.; Holben, W.E. 2006. Wildfire-produced charcoal directly influences nitrogen cycling in ponderosa pine forests. Soil Science Society of America Journal. 70(2): 448-453. doi:10.2136/sssaj2005.0096

DeMars, D.J.; Barrett, J.W. 1987. Ponderosa pine managed yield simulator: PPSIM users guide. Gen. Tech. Rep. PNW-GTR-203. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 36 p. https://www.fs.usda.gov/treesearch/pubs/8720

DeMars, C.J., Jr.; Roettgering, B.H. 1982. Western pine beetle. Forest Insect & Disease Leaflet 1. [Place of publication unknown]: USDA Forest Service. 8 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043087.pdf

Denevan, W.M. 1992. The pristine myth: the landscape of the Americas in 1492. Annals of the Association of American Geographers. 82(3): 369-385. doi:10.1111/j.1467-8306.1992.tb01965.x

Dezellem, D. 1983. White paper on managing existing understories and its effect on program harvest level for the Malheur National Forest. John Day, OR: USDA Forest Service, Malheur National Forest. 9 p.

Diaz-Avalos, C.; Peterson, D.L.; Alvarado, E.; Ferguson, S.A.; Besag, J.E. 2001. Space-time modelling of lightning-caused ignitions in the Blue Mountains, Oregon. Canadian Journal of Forest Research. 31(9): 1579-1593. doi:10.1139/x01-089

Dickman, A. 1978. Reduced fire frequency changes species composition of a ponderosa pine stand. Journal of Forestry. 76(1): 24-25. doi:10.1093/jof/76.1.24

Didion, M.; Kupferschmid, A.D.; Bugmann, H. 2009. Long-term effects of ungulate browsing on forest composition and structure. Forest Ecology and Management. 258(Supplement): S44-S55. doi:10.1016/j.foreco.2009.06.006

Dieterich, J.H.; Swetnam, T.W. 1984. Dendrochronology of a fire-scarred ponderosa pine. Forest Science. 30(1): 238-247. doi:10.1093/forestscience/30.1.238

Dietz, D.R.; Uresk, D.W.; Messner, H.E.; McEwen, L.C. 1980. Establishment, survival, and growth of selected browse species in a ponderosa pine forest. Res. Paper RM-219. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 11 p. Establishment_Survival_and_Growth_of_Sel

Diggins, C.; Fulé, P.Z.; Kaye, J.P.; Covington, W.W. 2010. Future climate affects management strategies for maintaining forest restoration treatments. International Journal of Wildland Fire. 19(7): 903-913. doi:10.1071/WF09109

Dodd, N.L.; Schweinsburg, R.E.; Boe, S. 2006. Landscape-scale forest habitat relationships to tassel-eared squirrel populations: implications for ponderosa pine forest restoration. Restoration Ecology. 14(4): 537-547. doi:10.1111/j.1526-100X.2006.00165.x

Dodge, M. 1972. Forest fuel accumulation – a growing problem. Science. 177(4044): 139-142. doi:10.1126/science.177.4044.139

Dodson, E.K.; Fiedler, C.E. 2006. Impacts of restoration treatments on alien plant invasion in *Pinus ponderosa* forests, Montana, USA. Journal of Applied Ecology. 43(5): 887-897. doi:10.1111/j.1365-2664.2006.01206.x

Dodson, E.K.; Peterson, D.W. 2010a. Dry coniferous forest restoration and understory plant diversity: the importance of community heterogeneity and the scale of observation. Forest Ecology and Management. 260(10): 1702-1707. doi:10.1016/j.foreco.2010.08.012

Dodson, E.K.; Peterson, D.W. 2010b. Mulching effects on vegetation recovery following high severity wildfire in north-central Washington State, USA. Forest Ecology and Management. 260(10): 1816-1823. doi:10.1016/j.foreco.2010.08.026

Dodson, E.K.; Root, H.T. 2013. Conifer regeneration following stand-replacing wildfire varies along an elevation gradient in a ponderosa pine forest, Oregon, USA. Forest Ecology and Management. 302: 163-170. doi:10.1016/j.foreco.2013.03.050

Dodson, E.K.; Peterson, D.W.; Harrod, R.J. 2008. Understory vegetation response to thinning and burning restoration treatments in dry conifer forests of the eastern Cascades, USA. Forest Ecology and Management. 255(8-9): 3130-3140. doi:10.1016/j.foreco.2008.01.026

Dolph, K.L.; Mori, S.R.; Oliver, W.W. 1995. Long-term response of old-growth stands to varying levels of partial cutting in the eastside pine type. Western Journal of Applied Forestry. 10(3): 101-108. doi:10.1093/wjaf/10.3.101

Donato, D.C.; Harvey, B.J.; Turner, M.G. 2016. Regeneration of montane forests 24 years after the 1988 Yellowstone fires: A fire-catalyzed shift in lower treelines? Ecosphere. 7(8): e01410 (16 p). doi:10.1002/ecs2.1410

Donovan, G.H.; Brown, T.C. 2007. Be careful what you wish for: the legacy of Smokey Bear. Frontiers in Ecology and the Environment. 5(2): 73-79. doi:10.1890/1540-9295(2007)5[73:BCWYWF]2.0.CO;2

Donovan, G.H.; Brown, T.C. 2008. Estimating the avoided fuel-treatment costs of wildfire. Western Journal of Applied Forestry. 23(4): 197-201. doi:10.1093/wjaf/23.4.197

Dore, S.; Kolb, T.E.; Montes-Helu, M.; Sullivan, B.W.; Winslow, W.D.; Hart, S.C.; Kaye, J.P.; Koch, G.W.; Hungate, B.A. 2008. Long-term impact of a stand-replacing fire on ecosystem CO2 exchange of a ponderosa pine forest. Global Change Biology. 14(8): 1801-1820. doi:10.1111/j.1365-2486.2008.01613.x

Dore, S.; Kolb, T.E.; Montes-Helu, M.; Eckert, S.E.; Sullivan, B.W.; Hungate, B.A.; Kaye, J.P.; Hart, S.C.; Koch, G.W.; Finkral, A. 2010. Carbon and water fluxes from ponderosa pine forests disturbed by wildfire and thinning. Ecological Applications. 20(3): 663-683. doi:10.1890/09-0934.1

Dore, S.; Montes-Helu, M.; Hart, S.C.; Hungate, B.A.; Koch, G.W.; Moon, J.B.; Finkral, A.J.; Kolb, T.E. 2012. Recovery of ponderosa pine ecosystem carbon and water fluxes from thinning and stand-replacing fire. Global Change Biology. 18(10): 3171-3185. doi:10.1111/j.1365-2486.2012.02775.x

Dove, N.C.; Safford, H.D.; Bohlman, G.N.; Estes, B.L.; Hart, S.C. 2020. High-severity wildfire leads to multi-decadal impacts on soil biogeochemistry in mixed-conifer forests. Ecological Applications. 30(4): e02072 (18 p). doi:10.1002/eap.2072

Downing, W. 2018. Fire refugia function and composition in dry mixed-conifer forests of Oregon's Blue Mountains. M.S. thesis. Corvallis, OR: Oregon State University, Department of Forest Ecosystems and Society. 143 p. https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/fn107433f

Downing, W.M.; Krawchuk, M.A.; Meigs, G.W.; Haire, S.L.; Coop, J.D.; Walker, R.B.; Whitman, E.; Chong, G.; Miller, C. 2019. Influence of fire refugia spatial pattern on post-fire forest recovery in Oregon's Blue Mountains. Landscape Ecology. 34(4): 771-792. doi:10.1007/s10980-019-00802-1

Drever, M.C.; Martin, K. 2010. Response of woodpeckers to changes in forest health and harvest: Implications for conservation of avian biodiversity. Forest Ecology and Management. 259(5): 958-966. doi:10.1016/j.foreco.2009.11.038

Driscoll, R.S. 1963. Repellents reduce deer browsing on ponderosa pine seedlings. Res. Note PNW-5. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p. https://archive.org/download/repellentsreduce05dris/repellentsreduce05dris.pdf

Dugan, A.J.; Birdsey, R.; Mascorro, V.S.; Magnan, M.; Smyth, C.E.; Olguin, M.; Kurz, W.A. 2018. A systems approach to assess climate change mitigation options in landscapes of the United States forest sector. Carbon Balance and Management. 13(1): 13 (14 p). doi:10.1186/s13021-018-0100-x

Dunn, C.J.; Bailey, J.D. 2012. Temporal dynamics and decay of coarse wood in early seral habitats of dry-mixed conifer forests in Oregon's Eastern Cascades. Forest Ecology and Management. 276: 71-81. doi:10.1016/j.foreco.2012.03.013

Dunn, C.J.; Bailey, J.D. 2015. Modeling the direct effects of salvage logging on long-term temporal fuel dynamics in dry-mixed conifer forests. Forest Ecology and Management. 341: 93-109. doi:10.1016/j.foreco.2015.01.002

Dunning, D. 1923. Some results of cutting in the Sierra forests of California. Bull. No. 1176. Washington, DC: U.S. Depart. of Agriculture. 24 p. Dunning 1923

Dunster, J.; Dunster, K. 1996. Dictionary of natural resource management. Vancouver, BC: UBC Press. 363 p. isbn:0-7748-0503-X

Durbin, K. 1992. Regenerating ravaged forests. Portland, OR: Portland Oregonian, November 30th, pages B1, B8.

East Oregonian. 1992. Forests in peril, a five-part series about forest health in the Blue Mountains. April 20-24.

Eaton, C.B. 1941. Influence of the mountain pine beetle on the composition of mixed pole stands of ponderosa pine and white fir. Journal of Forestry. 39(8): 710-713. doi:10.1093/jof/39.8.710

Eckberg, T.B.; Schmid, J.M.; Mata, S.A.; Lundquist, J.E. 1994. Primary focus trees for the mountain pine beetle in the Black Hills. Res. Note RM-RN-531. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 10 p. https://archive.org/download/primaryfocustree531eckb/primaryfocustree531eckb.pdf

Eckert, J.R. 1975. Roles of fire and allelopathy in ponderosa pine forests of the Colorado Front Range. Journal of Colorado-Wyoming Academy of Science. 7: 31.

Edminster, C.B. 1988. Stand density and stocking in even-aged ponderosa pine stands. In: Baumgartner, D.M.; Lotan, J.E., comps. Ponderosa pine: the species and its management; symposium proceedings. Pullman, WA: Washington State University, Department of Natural Resource Sciences, Cooperative Extension: 253-260.

Edminster, C.B.; Olsen, W.K. 1996. Thinning as a tool in restoring and maintaining diverse structure in stands of southwestern ponderosa pine. In: Covington, W.; Wagner, P.K., tech. coords. Conference on adaptive ecosystem restoration and management: restoration of cordilleran conifer landscapes of North America. Gen. Tech. Rep. RM-GTR-278. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 62-68. https://archive.org/download/CAT10754548/CAT10754548.pdf

Edmonds, R.L.; Agee, J.K.; Gara, R.I. 2005. Forest health and protection. Long Grove, IL: Waveland Press, Inc. 630 p. isbn:1-57766-396-9

Egan, J.E. 1954. Silvicultural foundations for national forest cutting practice in the ponderosa pine stands of the southwest. Journal of Forestry. 52(10): 756-766. doi:10.1093/jof/52.10.756

Egan, D. 2007. Conserving and restoring old growth in frequent-fire forests: cycles of disruption and recovery. Ecology and Society. 12(2): art23 [5 p]. http://www.ecologyandsociety.org/vol12/iss2/art23/

Egan, D.; Howell, E.A. 2001. The historical ecology handbook: a restorationist's guide to reference ecosystems. Washington, DC: Island Press. 457 p. isbn:1-55963-746-3

Egan, J.M.; Jacobi, W.R.; Negron, J.F.; Smith, S.L.; Cluck, D.R. 2010. Forest thinning and subsequent bark beetle-caused mortality in northeastern California. Forest Ecology and Management. 260(10): 1832-1842. doi:10.1016/j.foreco.2010.08.030

Eggemeyer, K.D.; Awada, T.; Harvey, F.E.; Wedin, D.A.; Zhou, X.; Zanner, C.W. 2009. Seasonal changes in depth of water uptake for encroaching trees *Juniperus virginiana* and *Pinus ponderosa* and two dominant C_4 grasses in a semiarid grassland. Tree Physiology. 29(2): 157-169. doi:10.1093/treephys/tpn019

Ehle, D.S.; Baker, W.L. 2003. Disturbance and stand dynamics in ponderosa pine forests in Rocky Mountain National Park, USA. Ecological Monographs. 73(4): 543-566. doi:10.1890/03-4014

Ellenwood, M.; Dilling, L.; Milford, J. 2012. Managing United States public lands in response to climate change: a view from the ground up. Environmental Management. 49(5): 954-967. doi:10.1007/s00267-012-9829-2

Elliott, K.J.; White, A.S. 1987. Competitive effects of various grasses and forbs on ponderosa pine seedlings. Forest Science. 33(2): 356-366. doi:10.1093/forestscience/33.2.356

Emmingham, W.H.; Oester, P.T.; Fitzgerald, S.A.; Filip, G.M.; Edge, W.D. 2005. Ecology and management of eastern Oregon forests: a comprehensive manual for forest managers. Manual 12. Corvallis, OR: Oregon State University, Extension Service. 208 p. isbn:1-931979-09-X

Endress, B.A.; Wisdom, M.J.; Vavra, M.; Parks, C.G.; Dick, B.L.; Naylor, B.J.; Boyd, J.M. 2012. Effects of ungulate herbivory on aspen, cottonwood, and willow development under forest fuels treatment regimes. Forest Ecology and Management. 276: 33-40. doi:10.1016/j.foreco.2012.03.019

Eng, M. 1998. Spatial patterns in forested landscapes: implications for biology and forestry. In: Voller, J.; Harrison, S., eds. Conservation biology principles for forested landscapes. Vancouver, BC: UBC Press: 42-75. isbn:0-7748-0630-3

Enright, N.J.; Fontaine, J.B.; Lamont, B.B.; Miller, B.P.; Westcott, V.C. 2014. Resistance and resilience to changing climate and fire regime depend on plant functional traits. Journal of Ecology. 102(6): 1572-1581. doi:10.1111/1365-2745.12306

Enright, N.J.; Fontaine, J.B.; Bowman, D.M.; Bradstock, R.A.; Williams, R.J. 2015. Interval squeeze: altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. Frontiers in Ecology and the Environment. 13(5): 265-272. doi:10.1890/140231

Entry, J.A.; Stark, N.M.; Loewenstein, H. 1986. Effect of timber harvesting on microbial biomass fluxes in a northern Rocky Mountain forest soil. Canadian Journal of Forest Research. 16(5): 1076-1081. doi:10.1139/x86-186

Entry, J.A.; Stark, N.M.; Loewenstein, H. 1987. Timber harvesting: Effects on degradation of cellulose and lignin. Forest Ecology and Management. 22(1-2): 79-88. doi:10.1016/0378-1127(87)90097-1

Erickson, C.C.; Waring, K.M. 2014. Old *Pinus ponderosa* growth responses to restoration treatments, climate and drought in a southwestern US landscape. Applied Vegetation Science. 17(1): 97-108. doi:10.1111/avsc.12056

Evangelista, P.H.; Kumar, S.; Stohlgren, T.J.; Young, N.E. 2011. Assessing forest vulnerability and the potential distribution of pine beetles under current and future climate scenarios in the interior West of the US. Forest Ecology and Management. 262(3): 307-316. doi:10.1016/j.foreco.2011.03.036

Evans, R.M. 1912. General silvical report; Wallowa and Minam Forests. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 54 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015545.pdf

Evans, J.W. 1991. Powerful rockey: the Blue Mountains and the Oregon Trail, 1811-1883. Enterprise, OR: Eastern Oregon State College; Pika Press. 374 p. isbn:0-9626772-0-5

Everett, R.; Hessburg, P.; Lehmkuhl, J.; Jensen, M.; Bourgeron, P. 1994. Old forests in dynamic landscapes: dry-site forests of eastern Oregon and Washington. Journal of Forestry. 92(1): 22-25. doi:10.1093/jof/92.1.22

Everett, R.; Schellhaas, R.; Anderson, T.; Lehmkuhl, J.; Camp, A. 1996. Restoration of ecosystem integrity and land use allocation objectives in altered watersheds. In: McDonnell, J.J.; Stribling, J.B.; Neville, L.R.; Leopold, D.J.; eds. Watershed restoration management: physical, chemical, and biological considerations. Syracuse, NY: American Water Resources Association: 271-280.

Everett, R.; Lehmkuhl, J.; Schellhaas, R.; Ohlson, P.; Keenum, D.; Riesterer, H.; Spurbeck, D. 1999. Snag dynamics in a chronosequence of 26 wildfires on the east slope of the Cascade Range in Washington state, USA. International Journal of Wildland Fire. 9(4): 223-234. doi:10.1071/WF00011

Everett, R.L.; Schellhaas, R.; Keenum, D.; Spurbeck, D.; Ohlson, P. 2000. Fire history in the ponderosa pine/Douglas-fir forests on the east slope of the Washington Cascades. Forest Ecology and Management. 129(1-3): 207-225. doi:10.1016/S0378-1127(99)00168-1

Everett, R.; Schellhaas, R.; Ohlson, P.; Spurbeck, D.; Keenum, D. 2003. Continuity in fire disturbance between riparian and adjacent sideslope Douglas-fir forests. Forest Ecology and Management. 175(1-3): 31-47. doi:10.1016/S0378-1127(02)00120-2

Everett, R.; Baumgartner, D.; Ohlson, P.; Schellhaas, R.; Harrod, R. 2007. Development of current stand structure in dry fir-pine forests of eastern Washington. Journal of the Torrey Botanical Society. 134(2): 199-214. doi:10.2307/20063911

Everett, R.L.; Baumgartner, D.; Ohlson, P.; Schellhaas, R. 2008. Structural classes and age structure in 1860 and 1940 reconstructed fir-pine stands of eastern Washington. Western North American Naturalist. 68(3): 278-290. doi:10.3398/1527-0904(2008)68[278:SCAASI]2.0.CO;2

Ex, S.A.; Smith, F.W. 2013. Stand density index estimates leaf area index in uneven-aged ponderosa pine stands. Western Journal of Applied Forestry. 28(1): 9-12. doi:10.5849/wjaf.12-004

Ex, S.A.; Smith, F.W. 2014a. Evaluating forest vegetation simulator performance for trees in multiaged ponderosa pine stands, Black Hills, USA. Forest Science. 60(2): 214-221. doi:10.5849/forsci.12-054

Ex, S.A.; Smith, F.W. 2014b. Wood production efficiency and growth dominance in multiaged and even-aged ponderosa pine stands. Forest Science. 60(1): 149-156. doi:10.5849/forsci.12-010

Eyre, F.H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p. isbn:978-0686306979

Fahnestock, G.R. 1968. Fire hazard from precommercial thinning of ponderosa pine. Res. Paper PNW-57. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p. https://www.fs.usda.gov/treesearch/pubs/25881

Faiella, S.M.; Bailey, J.D. 2007. Fluctuations in fuel moisture across restoration treatments in semi-arid ponderosa pine forests of northern Arizona, USA. International Journal of Wildland Fire. 16(1): 119-127. doi:10.1071/WF06018

Fairfax, E.; Whittle, A. 2020. Smokey the Beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western United States. Ecological Applications. 30(8): e02225 (8 p). doi:10.1002/eap.2225

Fairweather, M.L.; Rokala, E.A.; Mock, K.E. 2014. Aspen seedling establishment and growth after wildfire in central Arizona: An instructive case history. Forest Science. 60(4): 703-712. doi:10.5849/forsci.13-048

Fajardo, A.; Goodburn, J.M.; Graham, J. 2006. Spatial patterns of regeneration in managed uneven-aged ponderosa pine/Douglas-fir forests of western Montana, USA. Forest Ecology and Management. 223(1-3): 255-266. doi:10.1016/j.foreco.2005.11.022

Fajardo, A.; Graham, J.M.; Goodburn, J.M.; Fiedler, CE. 2007. Ten-year responses of ponderosa pine growth, vigor, and recruitment to restoration treatments in the Bitterroot Mountains, Montana, USA. Forest Ecology and Management. 243(1): 50-60. doi:10.1016/j.foreco.2007.02.006

Falk, D. 1990. Discovering the future, creating the past: some reflections on restoration. Restoration and Management Notes. 8(2): 71-72. http://er.uwpress.org/content/8/2/71.full.pdf

Falk, D.A. 2006. Process-centered restoration in a fire-adapted ponderosa pine forest. Journal for Nature Conservation. 14(3-4): 140-151. doi:10.1016/j.jnc.2006.04.005

Falk, D.; Miller, C.; McKenzie, D.; Black, A. 2007. Cross-scale analysis of fire regimes. Ecosystems. 10(5): 809-823. doi:10.1007/s10021-007-9070-7

Fan, Z.; Moore, J.A.; Shafii, B.; Osborne, H.L. 2002. Three-year response of ponderosa pine seedlings to controlled release fertilizer applied at planting. Western Journal of Applied Forestry. 17(3): 154-164. doi:10.1093/wjaf/17.3.154

Farris, C.A.; Baisan, C.H.; Falk, D.A.; Yool, S.R.; Swetnam, T.W. 2010. Spatial and temporal corroboration of a fire-scar-based fire history in a frequently burned ponderosa pine forest. Ecological Applications. 20(6): 1598-1614. doi:10.1890/09-1535.1

Farris, C.A.; Baisan, C.H.; Falk, D.A.; Van Horne, M.L.; Fulé, P.Z.; Swetnam, T.W. 2013. A comparison of targeted and systematic fire-scar sampling for estimating historical fire frequency in south-western ponderosa pine forests. International Journal of Wildland Fire. 22(8): 1021-1033. doi:10.1071/WF13026

Feddema, J.J.; Mast, J.N.; Savage, M. 2013. Modeling high-severity fire, drought and climate change impacts on ponderosa pine regeneration. Ecological Modelling. 253: 56-69. doi:10.1016/j.ecolmodel.2012.12.029

Fedkiw, J. [1999.] Managing multiple uses on national forests, 1905-1995; a 90-year learning experience and it isn't finished yet. FS-628. Washington, DC: USDA Forest Service. 284 p. https://ir.library.oregonstate.edu/xmlui/handle/1957/27305?show=full

Feeney, S.R.; Kolb, T.E.; Covington, W.W.; Wagner, M.R. 1998. Influence of thinning and burning restoration treatments on presettlement ponderosa pines at the Gus Pearson Natural Area. Canadian Journal of Forest Research. 28(9): 1295-1306. doi:10.1139/x98-103

Fellin, D.G.; Dewey, J.E. 1986. Western spruce budworm. Forest Insect & Disease Leaflet 53. [Place of publication unknown]: USDA Forest Service. 10 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043445.pdf

Ferguson, D.E. 1994. Advance regeneration in the inland west: considerations for individual tree and forest health. Journal of Sustainable Forestry. 2(3-4): 411-422. doi:10.1300/J091v02n03_11

Ferguson, S.A. 2001. Climatic variability in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 62-69. http://hdl.handle.net/2376/982

Ferguson, D.E.; Applegate, V.J.; Aune, P.S.; Carlson, C.E.; Geier-Hayes, K.; Graham, R.T.; Jacobsen, G.L.; Jain, T.B.; Powell, D.C.; Shepperd, W.D.; Sloan, J.P.; Youngblood, A. 1998. Communicating the role of silviculture and Forest Service silviculture research in the interior West. In: Murphy, D.; Loftus, N. Communicating the role of silviculture in managing the national forests: proceedings of the National Silviculture Workshop. Gen. Tech. Rep. NE-238. Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station: 104-109. http://www.treesearch.fs.fed.us/pubs/15099

Fernandes, P.M.; Botelho, H.S. 2003. A review of prescribed burning effectiveness in fire hazard reduction. International Journal of Wildland Fire. 12(2): 117-128. doi:10.1071/WF02042

Ferrell, G.T. 1986. Fir engraver. Forest Insect & Disease Leaflet 13. [Place of publication unknown]: USDA Forest Service. 8 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_042951.pdf

Fettig, C.; McKelvey, S. 2014. Resiliency of an interior ponderosa pine forest to bark beetle infestations following fuel-reduction and forest-restoration treatments. Forests. 5(1): 153. doi:10.3390/f5010153

Fettig, C.J.; McMillin, J.D.; Anhold, J.A.; Hamud, S.M.; Borys, R.R.; Dabney, C.P.; Seybold, S.J. 2006. The effects of mechanical fuel reduction treatments on the activity of bark beetles (Coleoptera: Scolytidae) infesting ponderosa pine. Forest Ecology and Management. 230(1-3): 55-68. doi:10.1016/j.foreco.2006.04.018

Fettig, C.J.; Klepzig, K.D.; Billings, R.F.; Munson, A.S.; Nebeker, T.E.; Negron, J.F.; Nowak, J.T. 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forests of the western and southern United States. Forest Ecology and Management. 238(1-3): 24-53. doi:10.1016/j.foreco.2006.10.011

Fettig, C.J.; Borys, R.R.; McKelvey, S.R.; Dabney, C.P. 2008. Blacks Mountain Experimental Forest: bark beetle responses to differences in forest structure and the application of prescribed fire in interior ponderosa pine. Canadian Journal of Forest Research. 38(5): 924-935. doi:10.1139/X07-243

Fettig, C.; Borys, R.; Dabney, C. 2010a. Effects of fire and fire surrogate treatments on bark beetle-caused tree mortality in the southern Cascades, California. Forest Science. 56(1): 60-73. doi:10.1093/forestscience/56.1.60

Fettig, C.J.; McKelvey, S.R.; Cluck, D.R.; Smith, S.L.; Otrosina, W.J. 2010b. Effects of prescribed fire and season of burn on direct and indirect levels of tree mortality in ponderosa and Jeffrey pine forests in California, USA. Forest Ecology and Management. 260(2): 207-218. doi:10.1016/j.foreco.2010.04.019

Fettig, C.J.; Mortenson, L.A.; Bulaon, B.M.; Foulk, P.B. 2019. Tree mortality following drought in the central and southern Sierra Nevada, California, U.S. Forest Ecology and Management. 432: 164-178. doi:10.1016/j.foreco.2018.09.006

Ffolliott, P.F.; Clary, W.P.; Larson, F.R. 1977. Effects of a prescribed fire in an Arizona ponderosa pine forest. Res. Note RM-336. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/CAIN779065666/CAIN779065666.pdf

Ffolliott, P.F.; Baker, M.B., Jr.; Gottfried, G.J. 2000. Heavy thinning of ponderosa pine stands: an Arizona case study. Res. Paper RMRS-RP-22. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 6 p. https://www.fs.usda.gov/treesearch/pubs/6044

Ffolliott, P.F.; Stropki, C.L.; Chen, H.; Neary, D.G. 2011. The 2002 Rodeo-Chediski Wildfire's impacts on southwestern ponderosa pine ecosystems, hydrology, and fuels. Res. Paper RMRS-RP-85. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 36 p. http://www.treesearch.fs.fed.us/pubs/38118

Fialko, K.; Ex, S.; Wolk, B.H. 2020. Ecological niches of tree species drive variability in conifer regeneration abundance following fuels treatments. Forest Ecology and Management. 476: 118475 (13 p). doi:10.1016/j.foreco.2020.118475

Fiddler, G.O.; McDonald, P.M. 1997. Mechanical and chemical release in a 12-year-old ponderosa pine plantation. Res. Paper PSW-RP-232. Berkeley, CA: USDA Forest Service, Pacific Southwest Research Station. 12 p. https://www.fs.usda.gov/treesearch/pubs/6930

Fiddler, G.O.; McDonald, P.M. 1999. Treatment duration and time since disturbance affect vegetation development in a young ponderosa pine plantation. Res. Note PSW-RN-424. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 8 p. https://www.fs.usda.gov/treesearch/pubs/2865

Fiddler, G.O.; Hart, D.R.; Fiddler, T.A.; McDonald, P.M. 1989. Thinning decreases mortality and increases growth of ponderosa pine in northeastern California. Res. Pap. PSW-194. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 7 p. http://www.treesearch.fs.fed.us/pubs/29118

Fiedler, C.E. 1996. Silvicultural applications: Restoring ecological structure and process in ponderosa pine forests. In: Hardy, C.C.; Arno, S.F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station: 39-40. https://www.fs.usda.gov/treesearch/pubs/28487

Fiedler, C.E. 2000a. Restoration treatments promote growth and reduce mortality of old-growth ponderosa pine (Montana). Ecological Restoration. 18(2): 117-119. doi:10.3368/er.18.2.117

Fiedler, C.E. 2000b. Silvicultural treatments. In: Smith, H.Y., ed. The Bitterroot Ecosystem Management Research Project: what we have learned. Proceedings RMRS-P-17. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 19-20. http://www.treesearch.fs.fed.us/pubs/21649

Fiedler, C.E.; Harrington, M.G. 2004. Restoring vigor and reducing hazard in an old-growth western larch stand (Montana). Ecological Restoration. 22(2): 133-134. doi:10.3368/er.22.2.131

Fiedler, C.E.; Arno, S.F.; Carlson, C.E.; Harrington, M.G. 1992. Management prescriptions for restoring biodiversity in inland northwest ponderosa pine-fir forests. Northwest Environmental Journal. 8(1): 211-213.

Fiedler, C.E.; Arno, S.F.; Harrington, M.G. 1996. Flexible silvicultural and prescribed burning approaches for improving health of ponderosa pine forests. In: Covington, W.; Wagner, P.K., tech. coords. Conference on adaptive ecosystem restoration and management: restoration of cordilleran conifer landscapes of North America. Gen. Tech. Rep. RM-GTR-278. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 69-74. https://archive.org/download/CAT10754548/CAT10754548.pdf

Fiedler, C.E.; Keegan, C.E.; Arno, S.F. 1997. Utilization as a component of restoring ecological processes in ponderosa pine forests. In: Barbour, R.J.; Skog, K.E., eds. Role of wood production in ecosystem management: proceedings of the sustainable forestry working group at the IUFRO A11 Division 5 conference. Gen. Tech. Rep. FPL-GTR-100. Madison, WI: USDA Forest Service, Forest Products Laboratory: 24-28. https://www.fs.usda.gov/treesearch/pubs/5659

Fiedler, C.E.; Arno, S.F.; Harrington, M.G. 1998. Reintroducing fire in ponderosa pine-fir forests after a century of fire exclusion. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL: Tall Timbers Research Station: 245-249. https://talltimbers.org/wp-content/uploads/2018/09/245-Fiedleretal1998_op.pdf

Fiedler, C.E.; Keegan, C.E., III; Wichman, D.P.; Arno, S.F. 1999. Product and economic implications of ecological restoration. Forest Products Journal. 49(2): 19-23. 2432/docview/214624470/abstract/13E56B4215955D58C6/10

Fiedler, C.E.; Arno, S.F.; Keegan, C.E.; Blatner, K.A. 2001. Overcoming America's wood deficit: an overlooked option. BioScience. 51(1): 53-58. doi:10.1641/0006-3568(2001)051[0053:OASWDA]2.0.CO;2

Fiedler, C.E.; Keegan, C.E.; Woodall, C.W.; Morgan, T.A. 2004. A strategic assessment of crown fire hazard in Montana: potential effectiveness and costs of hazard reduction treatments. Gen. Tech. Rep. PNW-GTR-622. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 48 p. http://www.treesearch.fs.fed.us/pubs/7448

Fiedler, C.E.; Metlen, K.L.; Dodson, E.K. 2006. Restoration/fuels reduction treatments differentially affect native and exotic understory species in a ponderosa pine forest (Montana). Ecological Restoration. 24(1): 44-46. doi:10.3368/er.24.1.41

Fiedler, C.E.; Friederici, P.; Petruncio, M.; Denton, C.; Hacker, W.D. 2007a. Managing for old growth in frequent-fire landscapes. Ecology and Society. 12(2): art20 (12 p). https://www-ecologyandsociety-org.nal.idm.oclc.org/vol12/iss2/art20/

Fiedler, C.E.; Friederici, P.; Petruncio, M. 2007b. Monitoring old growth in frequent-fire landscapes. Ecology and Society. 12(2): art22 (9 p). https://www-ecologyandsociety-org.nal.idm.oclc.org/vol12/iss2/art22/

Fiedler, C.E.; Metlen, K.L.; Dodson, E.K. 2010. Restoration treatment effects on stand structure, tree growth, and fire hazard in a ponderosa pine/Douglas-fir forest in Montana. Forest Science. 56(1): 18-31. doi:10.1093/forestscience/56.1.18

Fight, R.D.; Barbour, R.J. 2006. Financial analysis of fuel treatments on national forests in the western United States. Res. Note PNW-RN-555. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 10 p. https://www.fs.usda.gov/treesearch/pubs/25264

Fight, R.D.; Bolon, N.A.; Cahill, J.M. 1993. Financial analysis of pruning Douglas-fir and ponderosa pine in the Pacific Northwest. Western Journal of Applied Forestry. 8(2): 58-61. doi:10.1093/wjaf/8.2.58

Fight, R.D.; Gicqueau, A.; Hartsough, B.R. 1999. Harvesting costs for management planning for ponderosa pine plantations. Gen. Tech. Rep. PNW-GTR-467. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 8 p. https://www.fs.usda.gov/treesearch/pubs/2976

Filip, G.M. 1994. Forest health decline in central Oregon: a 13-year case study. Northwest Science. 68(4): 233-240. http://hdl.handle.net/2376/1557

Filip, G.M.; Parks, C.A. 1987. Simultaneous infestation of dwarf mistletoe and western spruce budworm decreased growth of Douglas-fir in the Blue Mountains of Oregon. Forest Science. 33(3): 767-773. doi:10.1093/forestscience/33.3.767

Filip, G.M.; Roth, L.F. 1987. Seven chemicals fail to protect ponderosa pine from Armillaria root disease in central Washington. Research Note PNW-RN-460. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 5 p. https://www.fs.usda.gov/treesearch/pubs/25074

Filip, G.M.; Schmitt, C.L. 1990. Rx for *Abies*: silvicultural options for diseased firs in Oregon and Washington. Gen. Tech. Rep. PNW-GTR-252. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 34 p. https://www.fs.usda.gov/treesearch/pubs/9100

Filip, G.M.; Yang-Erve, L. 1997. Effects of prescribed burning on the viability of *Armillaria ostoyae* in mixed-conifer forest soils in the Blue Mountains of Oregon. Northwest Science. 71(2): 137-144. http://hdl.handle.net/2376/1247

Filip, G.M.; Goheen, D.J.; Johnson, D.W.; Thompson, J.H. 1989. Precommercial thinning in a ponderosa pine stand affected by Armillaria root disease: 20 years of growth and mortality in central Oregon. Western Journal of Applied Forestry. 4(2): 58-59. doi:10.1093/wjaf/4.2.58

Filip, G.M.; Colbert, J.J.; Shaw, C.G., III; Hessburg, P.F.; Hosman, K.P. 1993. Influence of dwarf mistletoe and western spruce budworm on growth and mortality of Douglas-fir in unmanaged stands. Forest Science. 39(3): 465-477. doi:10.1093/forestscience/39.3.465

Filip, G.M.; Parks, C.A.; Wickman, B.E.; Mitchell, R.G. 1995. Tree wound dynamics in thinned and unthinned stands of grand fir, ponderosa pine, and lodgepole pine in eastern Oregon. Northwest Science. 69(4): 276-283. http://hdl.handle.net/2376/1306

Filip, G.M.; Torgersen, T.R.; Parks, C.A.; Mason, R.R.; Wickman, B.E. 1996. Insect and disease factors in the Blue Mountains. In: Jaindl, R.G.; Quigley, T.M., eds. Search for a solution: sustaining the land, people, and economy of the Blue Mountains. Washington, DC: American Forests: 169-202.

Filip, G.M.; Fitzgerald, S.A.; Ganio, L.M. 1999. Precommercial thinning in a ponderosa pine stand affected by Armillaria root disease in central Oregon: 30 years of growth and mortality. Western Journal of Applied Forestry. 14(3): 144-148. doi:10.1093/wjaf/14.3.144

Filip, G.M.; Fitzgerald, S.A.; Chadwick, K.L.; Max, T.A. 2009. Thinning ponderosa pine affected by Armillaria root disease: 40 years of growth and mortality on an infected site in central Oregon. Western Journal of Applied Forestry. 24(2): 88-94. doi:10.1093/wjaf/24.2.88

Finkral, A.J.; Evans, A.M. 2008. The effects of a thinning treatment on carbon stocks in a northern Arizona ponderosa pine forest. Forest Ecology and Management. 255(7): 2743-2750. doi:10.1016/j.foreco.2008.01.041

Finney, M.A.; Seli, R.C.; McHugh, C.W.; Ager, A.A.; Bahro, B.; Agee, J.K. 2007. Simulation of long-term landscape-level fuel treatment effects on large wildfires. International Journal of Wildland Fire. 16(6): 712-727. doi:10.1071/WF06064

Fischer, W.C. 1980. Prescribed fire and bark beetle attack in ponderosa pine forests. Fire Management Notes. 41(2): 10-12. http://www.fs.usda.gov/sites/default/files/legacy_files/fire-management-today/041_02.pdf

Fischer, W.C.; Miller, M.; Johnston, C.M.; Smith, J.K.; Simmerman, D.G.; Brown, J.K. 1996. Fire Effects Information System: user's guide. Gen. Tech. Rep. INT-GTR-327. Ogden, UT: USDA Forest Service, Intermountain Research Station. 131 p. https://www.feis-crs.org/feis/

Fischer, A.P.; Kline, J.D.; Ager, A.A.; Charnley, S.; Olsen, K.A. 2014. Objective and perceived wildfire risk and its influence on private forest landowners' fuel reduction activities in Oregon's (USA) ponderosa pine ecoregion. International Journal of Wildland Fire. 23(1): 143-153. doi:10.1071/WF12164

Fischer, A.P.; Spies, T.A.; Steelman, T.A.; Moseley, C.; Johnson, B.R.; Bailey, J.D.; Ager, A.A.; Bourgeron, P.; Charnley, S.; Collins, B.M.; Kline, J.D.; Leahy, J.E.; Littell, J.S.; Millington, J.D.; Nielsen-Pincus, M.; Olsen, C.S.; Paveglio, T.B.; Roos, Christopher I.; Steen-Adams, M.M.; Stevens, F.R.; Vukomanovic, J.; White, E.M.; Bowman, D.M. 2016. Wildfire risk as a socioecological pathology. Frontiers in Ecology and the Environment. 14(5): 276-284. doi:10.1002/fee.1283

Fisher, G.M. 1935. Comparative germination of tree species on various kinds of surface-soil material in the western white pine type. Ecology. 16(4): 606-611. doi:10.2307/1932591

Fisher, R.F. 1980. Allelopathy: a potential cause of regeneration failure. Journal of Forestry. 78: 346-350. doi:10.1093/jof/78.6.346

Fisher, F.M.; Gosz, J.R. 1986. Effects of trenching on soil processes and properties in a New Mexico mixed-conifer forest. Biology and Fertility of Soils. 2(1): 35-42. doi:10.1007/BF00638959

Fiske, J.; Tappeiner, J. 2005. An overview of key silvicultural information for ponderosa pine. In: Ritchie, M.W.; Maguire, D.A.; Youngblood, A., tech. coords. Proceedings of the symposium on ponderosa pine: Issues, trends, and management. Gen. Tech. Rep PSW-GTR-198. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 33-47. https://www.fs.usda.gov/treesearch/pubs/27255

Fitch, R.A.; Kim, Y.S.; Waltz, A.E.M.; Crouse, J.E. 2018. Changes in potential wildland fire suppression costs due to restoration treatments in northern Arizona ponderosa pine forests. Forest Policy and Economics. 87: 101-114. doi:10.1016/j.forpol.2017.11.006

Fitzgerald, S.A., ed. 2002. Fire in Oregon's forests: risks, effects, and treatment options. Unnumbered Rep. Portland, OR: Oregon Forest Resources Institute. 164 p.

Fitzgerald, S.A. 2005. Fire ecology of ponderosa pine and the rebuilding of fire-resilient ponderosa pine ecosystems. In: Ritchie, M.W.; Maguire, D.A.; Youngblood, A., tech. coords. Proceedings of the symposium on ponderosa pine: issues, trends, and management. Gen. Tech. Rep. PSW-GTR-198. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 197-225. https://www.fs.usda.gov/treesearch/pubs/27269

Fitzgerald, S.A.; Emmingham, W.H.; Filip, G.M.; Oester, P.T. 2000. Exploring methods for maintaining old-growth structure in forests with a frequent-fire history: a case study. In: Moser, W.K.; Moser, C.F., eds. Fire and forest ecology: innovative silviculture and vegetation management. Tall Timbers Fire Ecology Conference Proceedings No. 21. Tallahassee, FL: Tall Timbers Research Station: 199-206. http://talltimbers.org/wp-content/uploads/2014/03/Fitzgeraldetal2000_op.pdf

Flanary, S.J.; Keane, R.E. 2020. Ponderosa pine mortality in the Bob Marshall Wilderness after successive fires over 14 years. Res. Note RMRS-RN-85. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 13 p. https://www.fs.usda.gov/treesearch/pubs/59332

Flannigan, M.D.; Amiro, B.D.; Logan, K.A.; Stocks, B.J.; Wotton, B.M. 2005. Forest fires and climate change in the 21st century. Mitigation and Adaptation Strategies for Global Change. 11: 847-859. doi:10.1007/s11027-005-9020-7

Fleischman, F.; Struthers, C.; Arnold, G.; Dockry, M.; Scott, T. 2020. US Forest Service implementation of the National Environmental Policy Act: Fast, variable, rarely litigated, and declining. Journal of Forestry. 118(4): 403-418. doi:10.1093/jofore/fvaa016

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology. 8(3): 629-644. doi:10.1046/j.1523-1739.1994.08030629.x

Flinn, M.A.; Wein, R.W. 1977. Depth of underground plant organs and theoretical survival during fire. Canadian Journal of Botany. 55(19): 2550-2554. doi:10.1139/b77-291

Flint, H.R. 1925. Fire resistance of northern Rocky Mountain conifers. Idaho Forester. 7: 7-10, 41-43.

Flora, D.F. 1966a. Economic guides for a method of precommercial thinning of ponderosa pine in the Northwest. Res. Paper PNW-31. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 10 p. https://archive.org/download/CAT92272771/CAT92272771.pdf

Flora, D.F. 1966b. Economic guides for ponderosa pine dwarfmistletoe control in young stands of the Pacific Northwest. Res. Pap. PNW-29. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p. https://archive.org/download/CAT92272769/CAT92272769.pdf

Flowers, R.; Kanaskie, A. 2007. Pine engraver beetle (*Ips pini*). Forest Health Note. Salem, OR: Oregon Department of Forestry. 2 p.

Foiles, M.W. 1962. An appraisal of logging damage to advance reproduction of ponderosa pine. Res. Note No. 99. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 4 p. Research Note

Foiles, M.W. 1970. Commercial thinning to produce ponderosa pine sawlogs in the Inland Empire. Res. Pap. INT-72. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 10 p. https://archive.org/download/commercialthinni72foil/commercialthinni72foil.pdf

Foiles, M.W.; Curtis, J.D. 1973. Regeneration of ponderosa pine in the northern Rocky Mountain-Intermountain region. Res. Pap. INT-145. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 44 p. https://archive.org/download/regenerationofpo145foil/regenerationofpo145foil.pdf

Fontaine, J.B.; Kennedy, P.L. 2012. Avian and small mammal response to fire severity and fire surrogate treatments in U.S. fire-prone forests: a meta-analysis. Ecological Applications. 22(5): 1547-1561. doi:10.1890/12-0009.1

Forman, R.T.T.; Godron, M. 1981. Patches and structural components for a landscape ecology. BioScience. 31(10): 733-740. doi:10.2307/1308780

Fornwalt, P.J.; Kaufmann, M.R. 2014. Understorey plant community dynamics following a large, mixed severity wildfire in a *Pinus ponderosa–Pseudotsuga menziesii* forest, Colorado, USA. Journal of Vegetation Science. 25(3): 805-818. doi:10.1111/jvs.12128

Fornwalt, P.; Kaufmann, M.; Huckaby, L.; Stohlgren, T. 2009. Effects of past logging and grazing on understory plant communities in a montane Colorado forest. Plant Ecology. 203(1): 99-109. doi:10.1007/s11258-008-9513-z

Foster, H.D. 1907. Report on the silvics of the Blue Mountains (E) National Forest, Oregon. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 1 p. On file with: USDA Forest Service, Umatilla National Forest, Supervisor's Office, Pendleton, OR.

Foster, H.D. 1908. Report on the silvics of the Blue Mountains (E) National Forest, Oregon. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 30 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015620.pdf

Foster, D.R.; Knight, D.H.; Franklin, J.F. 1998. Landscape patterns and legacies resulting from large, infrequent forest disturbances. Ecosystems. 1(6): 497-510. doi:10.1007/s100219900046.

Fowells, H.A. 1941. The period of seasonal growth of ponderosa pine and associated species. Journal of Forestry. 39(7): 601-608. doi:10.1093/jof/39.7.601

Fowells, H.A.; Kirk, B.M. 1945. Availability of soil moisture to ponderosa pine. Journal of Forestry. 43(8): 601-604. doi: 10.1093/jof/43.8.601

Fowler, J.F.; Sieg, C.H. 2004. Postfire mortality of ponderosa pine and Douglas-fir: a review of methods to predict tree death. Gen. Tech. Rep. RMRS-GTR-132. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 25 p. http://www.treesearch.fs.fed.us/pubs/6703

Fowler, J.F.; Sieg, C.H.; McMillin, J.; Allen, K.K.; Negrón, J.F.; Wadleigh, L.L.; Anhold, J.A.; Gibson, K.E. 2010a. Development of post-fire crown damage mortality thresholds in ponderosa pine. International Journal of Wildland Fire. 19(5): 583-588. doi:10.1071/WF08193

Fowler, J.F.; Sieg, C.H.; Wadleigh, L.L. 2010b. Effectiveness of litter removal to prevent cambial kill-caused mortality in northern Arizona ponderosa pine. Forest Science. 56(2): 166-171. doi:10.1093/forestscience/56.2.166

Franceschi, V.R.; Krokene, P.; Christiansen, E.; Krekling, T. 2005. Anatomical and chemical defenses of conifer bark against bark beetles and other pests. New Phytologist. 167(2): 353-376. doi:10.1111/j.1469-8137.2005.01436.x

Francis, D.; Ex, S.; Hoffman, C. 2018. Stand composition and aspect are related to conifer regeneration densities following hazardous fuels treatments in Colorado, USA. Forest Ecology and Management. 409: 417-424. doi:10.1016/j.foreco.2017.11.053

Frank, A.C. 2003. The restoration of historical variability in the ponderosa pine type on the Boise Basin Experimental Forest. M.S. thesis. Moscow, ID: University of Idaho. 119 p.

Franklin, J.F.; Agee, J.K. 2003. Forging a science-based national forest fire policy. Issues in Science and Technology. 20(1): 59-66. https://issues.org/franklin/

Franklin, J.F.; Dyrness, C.T. 1973. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 417 p. http://www.treesearch.fs.fed.us/pubs/26203

Franklin, J.F.; Johnson, K.N. 2011. Dry forest restoration principles and prescriptions. Unpub. Rep. [Place of publication unknown]: [Publisher unknown]. 12 p.

Franklin, J.F.; Johnson, K.N. 2012. A restoration framework for federal forests in the Pacific Northwest. Journal of Forestry. 110(8): 429-439. doi:10.5849/jof.10-006

Franklin J.F.; Van Pelt, R. 2004. Spatial aspects of structural complexity in old-growth forests. Journal of Forestry. 102(3): 22-28. doi:10.1093/jof/102.3.22

Franklin, J.F.; Cromack, K., Jr.; Denison, W.; McKee, A.; Maser, C.; Sedell, J.; Swanson, F.; Juday, G. 1981. Ecological characteristics of old-growth Douglas-fir forests. Gen. Tech. Rep. PNW-118. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 48 p. https://www.fs.usda.gov/treesearch/pubs/5546

Franklin, J.F.; Shugart, H.H.; Harmon, M.E. 1987. Tree death as an ecological process. BioScience. 37(8): 550-556. doi:10.2307/1310665

Franklin, J.F., Mitchell, R.J.; Palik, B.J. 2007. Natural disturbance and stand development principles for ecological forestry. Gen Tech. Rep. NRS-19. Newtown Square, PA: USDA Forest Service, Northern Research Station. 44 p. http://www.treesearch.fs.fed.us/pubs/13293

Franklin, J.F.; Hemstrom, M.A.; Van Pelt, R.; Buchanan, J.B. 2008. The case for active management of dry forest types in eastern Washington: perpetuating and creating old forest structures and functions. [Place of publication unknown]: Washington State Department of Natural Resources. 97 p. https://www.dnr.wa.gov/publications/lm_ess_eog_mgmt.pdf

Franklin, J.F.; Johnson, K.N.; Churchill, D.J.; Hagmann, K.; Johnson, D.; Johnston, J. 2013. Restoration of dry forests in eastern Oregon: A field guide. Portland, OR: Nature Conservancy. 202 p. Dry-Forest-Guide-2013

Freemuth, J.C. 2001. The fires next time. Boise, ID: Boise State University, Andrus Center for Public Policy. 24 p.

Fremont, J.C. 1845. Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and north California in the years 1843-'44. Washington, DC: Gales and Seaton, Printers. 707 p. https://archive.org/download/mobot31753002784947/mobot31753002784947.pdf

Fried, J.S.; Jain, T.B.; Sandquist, J. 2013. Modeled forest inventory data suggest climate benefits from fuels management. Fire Management Today. 73(2): 11-14. http://www.fs.fed.us/fire/fmt/fmt_pdfs/FMT73-2.pdf

Friederici, P., ed. 2003. Ecological restoration of southwestern ponderosa pine forests. Washington, DC: Island Press. 561 p. isbn:1-55963-653-X

Fritts, S.R.; Moorman, C.E.; Hazel, D.W.; Jackson, B.D. 2014. Biomass harvesting guidelines affect downed woody debris retention. Biomass and Bioenergy. 70: 382-391. doi:10.1016/j.biombioe.2014.08.010

Froehlich, H.A.; McNabb, D.H. 1984. Minimizing soil compaction in Pacific Northwest forests. In:

Stone, E.L., ed. Proceedings of Sixth North American Forest Soils Conference: forest soils and treatment impacts. Knoxville, TN: Univ. of Tennessee, Department of Forestry, Wildlife and Fisheries: 159-192. https://ir.library.oregonstate.edu/downloads/9c67ws83n

Froehlich, H.A.; Miles, D.W.R.; Robbins, R.W. 1986. Growth of young *Pinus ponderosa* and *Pinus contorta* on compacted soil in central Washington. Forest Ecology and Management. 15(4): 285-294. doi:10.1016/0378-1127(86)90165-9

Fry, D.L.; Stephens, S.L. 2006. Influence of humans and climate on the fire history of a ponderosa pine-mixed conifer forest in the southeastern Klamath Mountains, California. Forest Ecology and Management. 223(1-3): 428-438. doi:10.1016/j.foreco.2005.12.021

Fry, D.L.; Stephens, S.L.; Collins, B.M.; North, M.P.; Franco-Vizcaino, E.; Gill, S.J. 2014. Contrasting spatial patterns in active-fire and fire-suppressed Mediterranean climate old-growth mixed conifer forests. PLoS ONE. 9(2): e88985 (15 p). doi:10.1371/journal.pone.0088985

Fuchs, L.; Stevens, L.E.; Fulé, P.Z. 2019. Dendrochronological assessment of springs effects on ponderosa pine growth, Arizona, USA. Forest Ecology and Management. 435: 89-96. doi:10.1016/j.foreco.2018.12.049

Fujimura, K.E.; Smith, J.E.; Horton, T.R.; Weber, N.S.; Spatafora, J.W. 2005. Pezizalean mycorrhizas and sporocarps in ponderosa pine (*Pinus ponderosa*) after prescribed fires in eastern Oregon, USA. Mycorrhiza. 15(2): 79-86. doi:10.1007/s00572-004-0303-8

Fulé, P.Z. 2008. Does it make sense to restore wildland fire in changing climate? Restoration Ecology. 16(4): 526-531. doi:10.1111/j.1526-100X.2008.00489.x

Fulé, P.Z.; Covington, W.W.; Moore, M.M. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. Ecological Applications. 7(3): 895-908. doi:10.1890/1051-0761(1997)007[0895:DRCFEM]2.0.CO;2

Fulé, P.Z.; Waltz, A.E.M.; Covington, W.W.; Heinlein, T.A. 2001. Measuring forest restoration effectiveness in reducing hazardous fuels. Journal of Forestry. 99(11): 24-29. doi:10.1093/jof/99.11.24

Fulé, P.Z.; Verkamp, G.; Waltz, A.E.M.; Covington, W.W. 2002. Burning under old-growth ponderosa pines on lava soils. Fire Management Today. 62(3): 47-49. https://www.fs.fed.us/file/40951/download?token=KYblNH59

Fulé, P.Z.; Cocke, A.E.; Heinlein, T.A.; Covington, W.W. 2004a. Effects of an intense prescribed forest fire: Is it ecological restoration? Restoration Ecology. 12(2): 220-230. doi:10.1111/j.1061-2971.2004.00283.x

Fulé, P.Z.; Crouse, J.E.; Cocke, A.E.; Moore, M.M.; Covington, W.W. 2004b. Changes in canopy fuels and potential fire behavior 1880-2040: Grand Canyon, Arizona. Ecological Modelling. 175(3): 231-248. doi:10.1016/j.ecolmodel.2003.10.023

Fulé, P.Z.; Korb, J.E.; Wu, R. 2009. Changes in forest structure of a mixed conifer forest, southwestern Colorado, USA. Forest Ecology and Management. 258(7): 1200-1210. doi:10.1016/j.foreco.2009.06.015

Fulé, P.Z.; Crouse, J.E.; Roccaforte, J.P.; Kalies, E.L. 2012. Do thinning and/or burning treatments in western USA ponderosa or Jeffrey pine-dominated forests help restore natural fire behavior? Forest Ecology and Management. 269: 68-81. doi:10.1016/j.foreco.2011.12.025

Fulé, P.Z.; Swetnam, T.W.; Brown, P.M.; Falk, D.A.; Peterson, D.L.; Allen, C.D.; Aplet, G.H.; Battaglia, M.A.; Binkley, D.; Farris, C.; Keane, R.E.; Margolis, E.Q.; Grissino-Mayer, H.; Miller, C.; Sieg, C.H.; Skinner, C.; Stephens, S.L.; Taylor, A. 2013. Unsupported inferences of high-severity fire in historical dry forests of the western United States: response to Williams and Baker. Global Ecology and Biogeography. doi:10.1111/geb.12136

Fulé, P.Z.; Swetnam, T.W.; Brown, P.M.; Falk, D.A.; Peterson, D.L.; Allen, C.D.; Aplet, G.H.; Battaglia, M.A.; Binkley, D.; Farris, C.; Keane, R.E.; Margolis, E.Q.; Grissino-Mayer, H.; Miller, C.; Sieg, C.H.; Skinner, C.; Stephens, S.L.; Taylor, A. 2014. Unsupported inferences of high-severity fire in historical dry forests of the western United States: Response to Williams and Baker. Global Ecology and Biogeography. 23(7): 825-830. doi:10.1111/geb.12136

Furniss, M.M.; Kegley, S.J. 2014. Douglas-fir beetle. Forest Insect and Disease Leaflet 5; FS/R6/RO/FIDL#5-14/001. Portland, OR: USDA Forest Service, Pacific Northwest Region. 12 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043201.pdf

Furniss, M.J.; Staab, B.P.; Hazelhurst, S.; Clifton, C.F.; Roby, K.B.; Ilhadrt, B.L.; Larry, E.B.; Todd, A.H.; Reid, L.M.; Hines, S.J.; Bennett, K.A.; Luce, C.H.; Edwards, P.J. 2010. Water, climate change, and forests: watershed stewardship for a changing climate. Gen. Tech. Rep. PNW-GTR-812. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 75 p. http://www.treesearch.fs.fed.us/pubs/35295

Gabet, E.J.; Bookter, A. 2011. Physical, chemical and hydrological properties of ponderosa pine ash. International Journal of Wildland Fire. 20(3): 443-452. doi:10.1071/WF09105

Gail, F.W. 1921. Factors controlling the distribution of Douglas fir in semi-arid regions of the northwest. Ecology. 2(4): 281-291. doi:10.2307/1928982

Gaines, E.M.; Kotok, E.S. 1954. Thinning ponderosa pine in the southwest. Station Paper No. 17. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 20 p. https://archive.org/download/thinningponderos17gain/thinningponderos17gain.pdf

Gaines, W.L.; Haggard, M.; Lehmkuhl, J.F.; Lyons, A.L.; Harrod, R.J. 2007. Short-term response of land birds to ponderosa pine restoration. Restoration Ecology. 15(4): 670-678. doi:10.1111/j.1526-100X.2007.00279.x

Gaines, W.; Haggard, M.; Begley, J.; Lehmkuhl, J.; Lyons, A. 2010. Short-term effects of thinning and burning restoration treatments on avian community composition, density, and nest survival in the eastern Cascades dry forests, Washington. Forest Science. 56(1): 88-99. doi:10.1093/forestscience/56.1.88

Galbraith, W.A.; Anderson, E.W. 1970. Grazing history of the northwest. Journal of Range Management. 24(1): 6-12. https://journals.uair.arizona.edu/index.php/jrm/article/download/5876/5486

Gallant, A.L.; Hansen, A.J.; Councilman, J.S.; Monte, D.K.; Betz, D.W. 2003. Vegetation dynamics under fire exclusion and logging in a Rocky Mountain watershed, 1856-1996. Ecological Applications. 13(2): 385-403. doi:10.1890/1051-0761(2003)013[0385:VDUFEA]2.0.CO;2

Ganey, J.L.; Vojta, S.C. 2004. Characteristics of snags containing excavated cavities in northern Arizona mixed-conifer and ponderosa pine forests. Forest Ecology and Management. 199(2-3): 323-332. doi:10.1016/j.foreco.2004.05.042

Ganey, J.L.; Vojta, S.C. 2005. Changes in snag populations in northern Arizona mixed-conifer and ponderosa pine forests, 1997-2002. Forest Science. 51(5): 396-405. doi:10.1093/forestscience/51.5.396

Ganey, J.L.; Vojta, S.C. 2011. Tree mortality in drought-stressed mixed-conifer and ponderosa pine forests, Arizona, USA. Forest Ecology and Management. 261(1): 162-168. doi:10.1016/j.foreco.2010.09.048

Ganio, L.M.; Progar, R.A. 2017. Mortality predictions of fire-injured large Douglas-fir and ponderosa pine in Oregon and Washington, USA. Forest Ecology and Management. 390: 47-67.

doi:10.1016/j.foreco.2017.01.008

Gannett, H. 1902. The forests of Oregon. Professional Paper No. 4, Series H, Forestry, 1. Washington, DC: U.S. Department of the Interior, Geological Survey. 36 p. https://pubs.usgs.gov/pp/0004/report.pdf

GAO (General Accounting Office). 1999. Western national forests: a cohesive strategy is needed to address catastrophic wildfire threats. GAO/RCED-99-65. Washington, DC: U.S. General Accounting Office, Resources, Community, and Economic Development Division. 60 p. https://www.gao.gov/products/RCED-99-65

GAO (General Accounting Office). 2003. Wildland fire management: Additional actions required to better identify and prioritize lands needing fuels reduction. GAO-03-805. Washington, DC: U.S. General Accounting Office. 60 p. https://www.gao.gov/products/GAO-03-805

GAO (General Accounting Office). 2004. Wildland fires: Forest Service and BLM need better information and a systematic approach for assessing the risks of environmental effects. GAO-04-705. Washington, DC: U.S. General Accounting Office. 88 p. https://www.gao.gov/products/GAO-04-705

Garrett, L.K.; Raphael, M.G.; Dixon, R.D. 1996. White-headed woodpecker (*Picoides albolarvatus*). No. 252. Poole, A.; Gill, F., eds. The birds of North America. Philadelphia, PA and Washington, DC: Academy of Natural Sciences and American Ornithologists' Union. 23 p.

Garrison, M.T.; Moore, J.A.; Shaw, T.M.; Mika, P.G. 2000. Foliar nutrient and tree growth response of mixed-conifer stands to three fertilization treatments in northeast Oregon and north central Washington. Forest Ecology and Management. 132(2-3): 183-198. doi:10.1016/S0378-1127(99)00228-5

Gärtner, S.; Reynolds, K.M.; Hessburg, P.F.; Hummel, S.; Twery, M. 2008. Decision support for evaluating landscape departure and prioritizing forest management activities in a changing environment. Forest Ecology and Management. 256(10): 1666-1676. doi:10.1016/j.foreco.2008.05.053

Gartner, M.H.; Veblen, T.T.; Sherriff, R.L.; Schoennagel, T.L. 2012. Proximity to grasslands influences fire frequency and sensitivity to climate variability in ponderosa pine forests of the Colorado Front Range. International Journal of Wildland Fire. 21(5): 562-571. doi:10.1071/WF10103

Garton, E.O. 1987. Habitat requirements of avian predators. In: Brookes, M.H.; Campbell, R.W.; Colbert, J.J.; Mitchell, R.G.; Stark, R.W., tech. coords. Western spruce budworm. Tech. Bull. 1694. Washington, DC: USDA Forest Service, Cooperative State Research Service: 82-85. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1318&context=barkbeetles

Gast, W.R., Jr.; Scott, D.W.; Schmitt, C.; Clemens, D.; Howes, S.; Johnson, C.G., Jr.; Mason, R.; Mohr, F.; Clapp, R.A. 1991. Blue Mountains forest health report: "new perspectives in forest health." Portland, OR: USDA Forest Service, Pacific Northwest Region, Malheur, Umatilla, and Wallowa-Whitman National Forests. Irregular pagination. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015666.pdf

Gaylord, M.L.; Kolb, T.E.; Wallin, K.F.; Wagner, M.R. 2007. Seasonal dynamics of tree growth, physiology, and resin defenses in a northern Arizona ponderosa pine forest. Canadian Journal of Forest Research. 37(7): 1173-1183. doi:10.1139/X06-309

Gaylord, M.L.; Hofstetter, R.W.; Kolb, T.E.; Wagner, M.R. 2011. Limited response of ponderosa pine bole defenses to wounding and fungi. Tree Physiology. 31(4): 428-437. doi:10.1093/treephys/tpr025

Gayton, D. 1996. Fire-maintained ecosystems and the effects of forest ingrowth. Victoria, BC: British Columbia Ministry of Forests. 4 p. https://www.for.gov.bc.ca/hfd/pubs/docs/scv/SCV692.pdf

Gedalof, Z.; Peterson, D.L.; Mantua, N.J. 2005. Atmospheric, climatic, and ecological controls on extreme wildfire years in the northwestern United States. Ecological Applications. 15(1): 154-174. doi:10.1890/03-5116

Gedney, D.R. 1963. Toward complete use of eastern Oregon's forest resources. Res. Bull. PNW-3. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 71 p. https://www.fs.usda.gov/treesearch/pubs/26699

Gedney, D.R.; Azuma, D.L.; Bolsinger, C.L.; McKay, N. 1999. Western juniper in eastern Oregon. Gen. Tech. Rep. PNW-GTR-464. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 53 p. http://www.treesearch.fs.fed.us/pubs/3250

Geier-Hayes, K. 1987. Occurrence of conifer seedlings and their microenvironments on disturbed sites in central Idaho. Res. Pap. INT-383. Ogden, UT: USDA Forest Service, Intermountain Research Station. 12 p. https://archive.org/download/occurrenceofconi383geie/occurrenceofconi383geie.pdf

Geier-Hayes, K. 1994. Natural regeneration in two central Idaho grand fir habitat types. Res. Pap. INT-472. Ogden, UT: USDA Forest Service, Intermountain Research Station. 18 p. https://archive.org/download/naturalregenerat472geie/naturalregenerat472geie.pdf

Geils, B.W.; Hawksworth, F.G. 2002. Damage, effects, and importance of dwarf mistletoes. Chapter 5. In: Geils, B.W.; Tovar, J.C.; Moody, B., tech. coords. Mistletoes of North American conifers. Gen. Tech. Rep. RMRS-GTR-98. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 57-65. https://www.fs.usda.gov/treesearch/pubs/27738

Geist, J.M.; Strickler, G.S. 1978. Physical and chemical properties of some Blue Mountain soils in northeast Oregon. Res. Pap. PNW-236. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 19 p. https://archive.org/download/CAT92273165/CAT92273165.pdf

George, T.L.; Zack, S. 2008. Bird occupancy and richness in ponderosa pine forests with contrasting forest structure and fire history. Canadian Journal of Forest Research. 38(5): 936-942. doi:10.1139/X07-238

Getzin, S.; Wiegand, T.; Wiegand, K.; He, F. 2008. Heterogeneity influences spatial patterns and demographics in forest stands. Journal of Ecology. 96(4): 807-820. doi:10.1111/j.1365-2745.2008.01377.x

Gibson, K.; Kegley, S.; Bentz, B. 2009. Mountain pine beetle. Forest Insect & Disease Leaflet 2; FS-R6-RO-FIDL#2/002-2009. Portland, OR: USDA Forest Service, Pacific Northwest Region. 12 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_042835.pdf

Gildar, C.N.; Fulé, P.Z.; Covington, W.W. 2004. Plant community variability in ponderosa pine forest has implications for reference conditions. Natural Areas Journal. 24(2): 101-111. http://www.naturalareas.org/docs/v24_2_04_pp101_111.pdf

Gill, L.S.; Hawksworth, F.G. 1954. Dwarfmistletoe control in southwestern ponderosa pine forests under management. Journal of Forestry. 52(5): 347-353. doi:10.1093/jof/52.5.347

Gillett, N.P.; Weaver, A.J.; Zwiers, F.W.; Flannigan, M.D. 2004. Detecting the effect of climate change on Canadian forest fires. Geophysical Research Letters. 31: L18211. doi:10.1029/2004GLO20876

Gillette, N.E.; Vetter, R.S.; Mori, S.R.; Rudolph, C.R.; Welty, D.R. 2008. Response of grounddwelling spider assemblages to prescribed fire following stand structure manipulation in the southern Cascade Range. Canadian Journal of Forest Research. 38(5): 969-980. doi:10.1139/X07-245

Gisborne, H.T. 1926. Lightning and forest fires in the northern Rocky Mountain region. Monthly Weather Review. 54(7): 281-286. https://www.fs.usda.gov/treesearch/pubs/48900

Godbold, D.L. 1998. Stress concepts and forest trees. Chemosphere. 36(4-5): 859-864. doi:10.1016/S0045-6535(97)10138-2

Goeking, S.A.; Tarboton, D.G. 2020. Forests and water yield: A synthesis of disturbance effects on streamflow and snowpack in western coniferous forests. Journal of Forestry. 118(2): 172-192. doi:10.1093/jofore/fvz069

Goforth, B.R.; Minnich, R.A. 2008. Densification, stand-replacement wildfire, and extirpation of mixed conifer forest in Cuyamaca Rancho State Park, southern California. Forest Ecology and Management. 256(1-2): 36-45. doi:10.1016/j.foreco.2008.03.032

Goggans, R. 1985. Habitat use by flammulated owls in northeastern Oregon. M.S. thesis. Corvallis, OR: Oregon State University. 54 p.

Goheen, E.M.; Willhite, E.A. 2006. Field guide to the common diseases and insect pests of Oregon and Washington conifers. Portland, OR: USDA Forest Service, Pacific Northwest Region. 325 p. isbn:0-16-076244-8

Goldblum, D.; Veblen, T.T. 1992. Fire history of a ponderosa pine/Douglas fir forest in the Colorado Front Range. Physical Geography. 13(2): 133-148. doi:10.1080/02723646.1992.10642449

Gomez, A.G.; Powers, R.F.; Singer, M.J.; Horwath, W.R. 2002. N uptake and N status in ponderosa pine as affected by soil compaction and forest floor removal. Plant and Soil. 242(2): 263-275. doi:10.1023/A:1016218316381

Goodman, L. 2003 (June 11). Guidance for implementing Eastside Screens. Memorandum to Forest Supervisors of the Colville, Deschutes, Malheur, Ochoco, Umatilla, Wallowa-Whitman, Wenatchee-Okanogan, and Winema-Fremont national forests. Portland, OR: USDA Forest Service, Pacific Northwest Region, Regional Office. 4 p.

Goodwin, M.J.; North, M.P.; Zald, H.S.J.; Hurteau, M.D. 2018. The 15-year post-treatment response of a mixed-conifer understory plant community to thinning and burning treatments. Forest Ecology and Management. 429: 617-624. doi:10.1016/j.foreco.2018.07.058

Gordo, O.; Sanz, J.J. 2010. Impact of climate change on plant phenology in Mediterranean ecosystems. Global Change Biology. 16(3): 1082-1106. doi:10.1111/j.1365-2486.2009.02084.x

Gorte, R.W. 1995. Forest fires and forest health. Report for Congress 95-511 ENR. Washington, DC: Congressional Research Service. 5 p.

Gosz, J.R.; Asher, J.; Holder, B.; Knight, R.; Naiman, R.; Raines, G.; Stine, P.; Wigley, T.B. 1999. An ecosystem approach for understanding landscape diversity. In: Johnson, N.C.; Malk, A.J.; Szaro, R.C.; Sexton, W.T., eds. Ecological stewardship: a common reference for ecosystem management; volume II. Oxford, UK: Elsevier Science Ltd.: 157-194. isbn:0-08-043206-9

Gottfried, G.J. 1992. Growth and development in an old-growth Arizona mixed conifer stand following initial harvesting. Forest Ecology and Management. 54(1-4): 1-26. doi:10.1016/0378-1127(92)90002-Q

Gottfried, G.J.; Shaw, J.D.; Ford, P.L. 2008. Ecology, management, and restoration of pinon-juniper and ponderosa pine ecosystems: combined proceedings of the 2005 St. George, Utah and 2006 Albuquerque, New Mexico workshops. Proceedings RMRS-P-51. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 218 p. https://www.fs.usda.gov/treesearch/pubs/31158

Grady, K.C.; Hart, S.C. 2006. Influences of thinning, prescribed burning, and wildfire on soil processes and properties in southwestern ponderosa pine forests: A retrospective study. Forest Ecology and Management. 234(1-3): 123-135. doi:10.1016/j.foreco.2006.06.031

Graham, R.T.; Jain, T.B. 2002. Restoring dry forests of the inland northwestern United States. In: Proceedings of the IUFRO conference on restoration of boreal and temperate forests: documenting forest restoration knowledge and practices in boreal and temperate ecosystems. Denmark: Danish Center for Forest, Landscape and Planning: 155-156.

Graham, R.T.; Jain, T.B. 2005. Ponderosa pine ecosystems. In: Ritchie, M.W.; Maguire, D.A.; Youngblood, A., tech. coords. Proceedings of the symposium on ponderosa pine: issues, trends, and management. Gen. Tech. Rep. PSW-GTR-198. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 1-32. https://www.fs.usda.gov/treesearch/pubs/27254

Graham, R.T.; Harvey, A.E.; Jain, T.B.; Tonn, J.R. 1999. The effects of thinning and similar stand treatments on fire behavior in western forests. Gen. Tech. Rep. PNW-GTR-463. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 27 p. http://www.treesearch.fs.fed.us/pubs/2979

Graham, R.T.; McCaffrey, S.; Jain, T.B. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 43 p. http://www.treesearch.fs.fed.us/pubs/6279

Graham, R.T.; Asherin, L.A.; Battaglia, M.A.; Jain, T.; Mata, S.A. 2016. Mountain pine beetles: A century of knowledge, control attempts, and impacts central to the Black Hills. Gen. Tech. Rep. RMRS-GTR-353. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 193 p. https://www.fs.usda.gov/treesearch/pubs/52308

Graham, R.T.; Asherin, L.A.; Jain, T.B.; Baggett, L.S.; Battaglia, M.A. 2019. Differing ponderosa pine forest structures, their growth and yield, and mountain pine beetle impacts: Growing stock levels in the Black Hills. Gen. Tech. Rep. RMRS-GTR-393. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 102 p. https://www.fs.usda.gov/treesearch/pubs/58251

Grant, G.E.; Tague, C.L.; Allen, C.D. 2013. Watering the forest for the trees: an emerging priority for managing water in forest landscapes. Frontiers in Ecology and the Environment. 11(6): 314-321. doi:10.1890/120209

Gray, G.; Clark, L. 1992. The changing science of forest health. American Forests. 98(11/12): 13-16.

Grayson, L.M.; Progar, R.A.; Hood, S.M. 2017. Predicting post-fire tree mortality for 14 conifers in the Pacific Northwest, USA: Model evaluation, development, and thresholds. Forest Ecology and Management. 399: 213-226. doi:10.1016/j.foreco.2017.05.038

Greb, B.W.; Black, A.L. 1961. Effects of windbreak plantings on adjacent crops. Journal of Soil and Water Conservation. 16(5): 223-227.

Greeley, W.B. 1912. Timber sales on the national forests. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. [Place of publication unknown]: USDA Forest Service. 8 p. On file with: USDA Forest Service, Umatilla National Forest, Supervisor’s Office, Pendleton, OR.

Greeley, W.B. 1920. "Paiute forestry" or the fallacy of light burning. Timberman. 21(3): 38-39.

Greene, D.F.; Johnson, E.A. 2000. Tree recruitment from burn edges. Canadian Journal of Forest Research. 30(8): 1264-1274. doi:10.1139/x00-040

Greiner, S.M.; Grimm, K.E.; Waltz, A.E.M. 2020. Managing for resilience? Examining management implications of resilience in southwestern national forests. Journal of Forestry. 118(4): 433-443. doi:10.1093/jofore/fvaa006

Grier, C.C. 1975. Wildfire effects on nutrient distribution and leaching in a coniferous ecosystem. Canadian Journal of Forest Research. 5(4): 599-607. doi:10.1139/x75-087

Grier, C.C. 1989. Effects of prescribed springtime underburning on production and nutrient status of a young ponderosa pine stand. In: Tecle, A.; Covington, W.W.; Hamre, R.H., tech. coords. Multiresource management of ponderosa pine forests. Gen. Tech. Rep. RM-185. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 71-76. https://archive.org/download/CAT10400419/CAT10400419.pdf

Griffis, K.L.; Crawford, J.A.; Wagner, M.R.; Moir, W.H. 2001. Understory response to management treatments in northern Arizona ponderosa pine forests. Forest Ecology and Management. 146(1-3): 239-245. doi:10.1016/S0378-1127(00)00461-8

Griffis-Kyle, K.L.; Beier, P. 2003. Small isolated aspen stands enrich bird communities in southwestern ponderosa pine forests. Biological Conservation. 110(3): 375-385. doi:10.1016/S0006-3207(02)00237-9

Griffiths, D. 1903. Forage conditions and problems in eastern Washington, eastern Oregon, northeastern California, and northwestern Nevada. Bull. No. 38. Washington, DC: USDA Bureau of Plant Industry. 52 p. https://archive.org/download/forageconditions38grif/forageconditions38grif.pdf

Grossmann, E.B. 2000. Prescribed fire in eastern Oregon ponderosa pine forests: Relationships between soil fertility and ecology. MS thesis. Corvallis, OR: Oregon State University. 75 p. http://ir.library.oregonstate.edu/xmlui/handle/1957/6739

Gruell, G.E. 1985. Fire on the early western landscape: an annotated record of wildland fires 1776-1900. Northwest Science. 59(2): 97-105.

Gruell, G.E. 1986. Post-1900 mule deer irruptions in the Intermountain West: Principal cause and influences. Gen. Tech. Rep. INT-GTR-206. Ogden, UT: USDA Forest Service, Intermountain Research Station. 37 p. https://www.fs.usda.gov/treesearch/pubs/37804

Gruell, G.E. 2001. Fire in Sierra Nevada forests: a photographic interpretation of ecological change since 1849. Missoula, MT: Mountain Press Publishing Company. 238 p. isbn:0-87842-446-6

Gruell, G.E.; Schmidt, W.C.; Arno, S.F.; Reich, W.J. 1982. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana – implications for resource management. Gen. Tech. Rep. INT-130. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 42 p. https://archive.org/download/CAT83790017/CAT83790017.pdf

Grulke, N.E.; Retzlaff, W.A. 2001. Changes in physiological attributes of ponderosa pine from seedling to mature tree. Tree Physiology. 21(5): 275-286. doi:10.1093/treephys/21.5.275

Gundale, M.J.; DeLuca, T.H. 2006. Temperature and source material influence ecological attributes of ponderosa pine and Douglas-fir charcoal. Forest Ecology and Management. 231(1-3): 86-93. doi:10.1016/j.foreco.2006.05.004

Gundale, M.J.; DeLuca, T.H.; Fiedler, C.E.; Ramsey, P.W.; Harrington, M.G.; Gannon, J.E. 2005. Restoration treatments in a Montana ponderosa pine forest: effects on soil physical, chemical and biological properties. Forest Ecology and Management. 213(1-3): 25-38. doi:10.1016/j.foreco.2005.03.015

Gunderson, L.H.; Allen, C.R.; Holling, C.S. 2010. Foundations of ecological resilience. Washington, DC: Island Press. 466 p. isbn:978-1-59726-511-9

Gutsell, S.L.; Johnson, E.A. 1996. How fire scars are formed: coupling a disturbance process to its ecological effect. Canadian Journal of Forest Research. 26(2): 166-174. doi:10.1139/x26-020

Haase, S.M. 1986. Effect of prescribed burning on soil moisture and germination of southwestern ponderosa pine seed on basaltic soils. Res. Note RM-462Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 6 p. https://archive.org/download/IND86025157/IND86025157.pdf

Habeck, J.R. 1976. Forests, fuels and fire in the Selway-Bitterroot Wilderness, Idaho. In: Proceedings of the annual Tall Timbers fire ecology conference number 14. Tallahassee, FL: Tall Timbers Research Station: 305-353. https://talltimbers.org/wp-content/uploads/2018/09/305-Habeck1974_op.pdf

Habeck, J.R. 1987. Present-day vegetation in the northern Rocky Mountains. Annals of the Missouri Botanical Garden. 74(4): 804-840. doi:10.2307/2399451

Habeck, J.R. 1990. Old-growth ponderosa pine–western larch forests in western Montana: ecology and management. Northwest Environmental Journal. 6(2): 271-292.

Habeck, J.R. 1994. Using General Land Office records to assess forest succession in ponderosa pine/Douglas-fir forests in western Montana. Northwest Science. 68(2): 69-78. http://hdl.handle.net/2376/1545

Habeck, J.R.; Mutch, R.W. 1973. Fire-dependent forests in the northern Rocky Mountains. Quaternary Research. 3(3): 408-424. doi:10.1016/0033-5894(73)90006-9

Hadfield, J.; Carlson, D. 2008. Insects and fungi found in fire-killed ponderosa pines and Douglas-firs within the first year of tree death. [Place of publication unknown]: USDA Okanogan and Wenatchee National Forests. 22 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_026225.pdf

Hadfield, J.S.; Russell, K.W. 1978. Dwarf mistletoe management in the Pacific Northwest. In: Scharpf, R.F.; Parmeter, Jr., J.R., tech. coords. Proceedings of the symposium on dwarf mistletoe control through forest management. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station: 73-81. https://www.fs.usda.gov/treesearch/pubs/24083

Hadfield, J.S.; Mathiasen, R.L.; Hawksworth, F.G. 2000. Douglas-fir dwarf mistletoe. Forest Insect and Disease Leaflet 54; R6-NR-FID-PR-003-00. [Place of publication unknown]: USDA Forest Service. 9 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043663.pdf

Hadley, K.S.; Veblen, T.T. 1993. Stand response to western spruce budworm and Douglas-fir beetle outbreaks, Colorado Front Range. Canadian Journal of Forest Research. 23(3): 479-491. doi:10.1139/x93-066

Haeussler, S.; Kneeshaw, D. 2003. Comparing forest management to natural processes. Chapter 9. In: Burton, P.J.; Messier, C.; Smith, D.W.; Adamowicz, W.L., eds. Towards sustainable management of the boreal forest. Ottawa, ON: NRC Research Press: 307-368.

isbn:0-660-18762-0

Hagmann, R.K.; Franklin, J.F.; Johnson, K.N. 2013. Historical structure and composition of ponderosa pine and mixed-conifer forests in south-central Oregon. Forest Ecology and Management. 304: 492-504. doi:10.1016/j.foreco.2013.04.005

Hagmann, R.K.; Franklin, J.F.; Johnson, K.N. 2014. Historical conditions in mixed-conifer forests on the eastern slopes of the northern Oregon Cascade Range, USA. Forest Ecology and Management. 330: 158-170. doi:10.1016/j.foreco.2014.06.044

Hagmann, R.K.; Stevens, J.T.; Lydersen, J.M.; Collins, B.M.; Battles, J.J.; Hessburg, P.F.; Levine, C.R.; Merschel, A.G.; Stephens, S.L.; Taylor, A.H.; Franklin, J.F.; Johnson, D.L.; Johnson, K.N. 2018. Improving the use of early timber inventories in reconstructing historical dry forests and fire in the western United States: Comment. Ecosphere. 9(7): e02232 (10 p). doi:10.1002/ecs2.2232

Hagmann, R.K.; Merschel, A.G.; Reilly, M.J. 2019. Historical patterns of fire severity and forest structure and composition in a landscape structured by frequent large fires: Pumice Plateau ecoregion, Oregon, USA. Landscape Ecology. 34(3): 551-568. doi:10.1007/s10980-019-00791-1

Haig, I.T.; Davis, K.P.; Weidman, R.H. 1941. Natural regeneration in the western white pine type. Tech. Bull. No. 767. Washington, DC: U.S. Depart. of Agriculture. 98 p. http://www.fs.fed.us/rm/pubs/rmrs_gtr292/1941_haig.pdf

Haines, F. 1938. The northward spread of horses among the plains Indians. American Anthropologist. 40(3): 429-437. doi:10.2307/662040

Haire, S.L.; McGarigal, K. 2009. Changes in fire severity across gradients of climate, fire size, and topography: a landscape ecological perspective. Fire Ecology. 5(2): 86-103. doi:10.4996/fireecology.0502086

Haire, S.L.; McGarigal, K. 2010. Effects of landscape patterns of fire severity on regenerating ponderosa pine forests (*Pinus ponderosa*) in New Mexico and Arizona, USA. Landscape Ecology. 25(7): 1055-1069. doi:10.1007/s10980-010-9480-3

Hall, F.C. 1976. Fire and vegetation in the Blue Mountains – implications for land managers. In: Proceedings of the annual Tall Timbers fire ecology conference no. 15. Tallahassee, FL: Tall Timbers Research Station: 155-170. https://talltimbers.org/wp-content/uploads/2018/09/155-Hall1974_op.pdf

Hall, F.C. 1977. Ecology of natural underburning in the Blue Mountains of Oregon. R6-ECOL-79-001. Portland, OR: USDA Forest Service, Pacific Northwest Region. 11 p. Ecology_of_natural_underburning

Hall, F.C. 1980. Fire history – Blue Mountains, Oregon. In: Stokes, M.A.; Dieterich, J.H., tech. cords. Proceedings of the fire history workshop. Gen. Tech. Rep. RM-81. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 75-81. https://www.fs.usda.gov/treesearch/pubs/41408

Hall, F.C. 1991. Ecology of fire in the Blue Mountains of eastern Oregon. Unpub. Rep. Portland, OR, USDA Forest Service, Pacific Northwest Region. 27 p.

Hall, T.E.; Bigler-Cole, H. 2001. Sociocultural factors and forest health management. Northwest Science. 75(Special Issue): 208-233. http://hdl.handle.net/2376/998

Hall, F.C.; Bryant, L.; Clausnitzer, R.; Geier-Hayes, K.; Keane, R.; Kertis, J.; Shlisky, A.; Steele, R. 1995. Definitions and codes for seral status and structure of vegetation. Gen. Tech. Rep. PNW-GTR-363. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 39 p.

http://www.treesearch.fs.fed.us/pubs/5619

Hall, S.A.; Burke, I.C.; Hobbs, N.T. 2006. Litter and dead wood dynamics in ponderosa pine forests along a 160-year chronosequence. Ecological Applications. 16(6): 2344-2355. doi:10.1890/1051-0761(2006)016[2344:ladwdi]2.0.co;2

Hall Defrees, D.; Averett, J.P.; Wisdom, M.J.; Endress, B.A. 2020. Interactive effects of fuels reduction and large herbivores on shrub assemblages in dry conifer forests of the interior west, USA. Forest Ecology and Management. 463: 118031 (10 p). doi:10.1016/j.foreco.2020.118031

Halofsky, J.E.; Peterson, D.L. 2016. Climate change vulnerabilities and adaptation options for forest vegetation management in the northwestern USA. Atmosphere. 7(3): 46 (14 p). doi:10.3390/atmos7030046

Halofsky, J.E.; Peterson, D.L. 2017. Climate change vulnerability and adaptation in the Blue Mountains region. Gen. Tech. Rep. PNW-GTR-939. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 331 p. https://www.treesearch.fs.fed.us/pubs/53937

Halofsky, J.S.; Halofsky, J.E.; Burcsu, T.; Hemstrom, M.A. 2014a. Dry forest resilience varies under simulated climate-management scenarios in a central Oregon, USA landscape. Ecological Applications. 24(8): 1908-1925. doi:10.1890/13-1653.1

Halofsky, J.E.; Creutzburg, M.K.; Hemstrom, M.A. 2014b. Integrating social, economic, and ecological values across large landscapes. Gen. Tech. Rep. PNW-GTR-896. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 206 p. http://www.treesearch.fs.fed.us/pubs/47219

Halofsky, J.E.; Peterson, D.L.; Marcinkowski, K.W. 2015. Climate change adaptation in United States federal natural resource science and management agencies: a synthesis. ASIWG Synthesis. Washington, DC: U.S. Global Change Research Program. 80 p. http://www.globalchange.gov/sites/globalchange/files/ASIWG_Synthesis_4.28.15_final.pdf

Halofsky, J.; Peterson, D.; Metlen, K.; Myer, M.; Sample, V. 2016. Developing and implementing climate change adaptation options in forest ecosystems: A case study in southwestern Oregon, USA. Forests. 7(11): 268. doi:10.3390/f7110268

Halofsky, J.E.; Hoglund-Wyatt, K.; Dello, K.; Peterson, D.L.; Stevenson, J. 2018a. Assessing and adapting to climate change in the Blue Mountains, Oregon (USA): Overview, biogeography, and climate. Climate Services. 10: 1-8. doi: 10.1016/j.cliser.2018.03.002

Halofsky, J.E.; Peterson, D.L.; Prendeville, H.R. 2018b. Assessing vulnerabilities and adapting to climate change in northwestern U.S. forests. Climatic Change. 146(1-2): 89-102. doi:10.1007/s10584-017-1972-6

Halofsky, J.E.; Peterson, D.L.; Ho, J.J. 2019. Climate change vulnerability and adaptation in south-central Oregon. Gen. Tech. Rep. PNW-GTR-974. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 473 p. https://www.fs.usda.gov/treesearch/pubs/58688

Halofsky, J.E.; Peterson, D.L.; Harvey, B.J. 2020. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology. 16(1): 1-26. doi:10.1186/s42408-019-0062-8

Hamilton, L.C.; Hartter, J.; Stevens, F.; Congalton, R.G.; Ducey, M.J.; Campbell, M.; Maynard, D.; Staunton, M. 2012. Forest views: Northeast Oregon survey looks at community and environment. Issue Brief No. 47. Durham, NH: University of New Hampshire, Carsey Institute. 12 p. www.carseyinstitute.unh.edu

Hamilton, L.C.; Hartter, J.; Safford, T.G.; Stevens, F.R. 2014. Rural environmental concern: Effects of position, partisanship, and place. Rural Sociology. 79(2): 257-281. doi:10.1111/ruso.12023

Hamilton, L.C.; Hartter, J.; Lemcke-Stampone, M.; Moore, D.W.; Safford, T.G. 2015a. Tracking public beliefs about anthropogenic climate change. PLoS ONE. 10(9): e0138208. doi:10.1371/journal.pone.0138208

Hamilton, L.C.; Hartter, J.; Safford, T.G. 2015b. Validity of county-level estimates of climate change beliefs. Nature Climate Change. 5(8): 704-704. doi:10.1038/nclimate2720

Hamilton, L.C.; Hartter, J.; Keim, B.D.; Boag, A.E.; Palace, M.W.; Stevens, F.R.; Ducey, M.J. 2016. Wildfire, climate, and perceptions in northeast Oregon. Regional Environmental Change. 16(6): 1819-1832. doi:10.1007/s10113-015-0914-y

Hammer, K.J. 2001. Ponderosa poster child: U.S. Forest Service misrepresenting the historic condition of western forests and the effects of fire suppression and logging. Kalispell, MT: Friends of the Wild Swan and Swan View Coalition. 8 p.

Hamrick, J.L.; Blanton, H.M.; Hamrick, K.J. 1989. Genetic structure of geographically marginal populations of ponderosa pine. American Journal of Botany. 76(11): 1559-1568. doi:10.2307/2444394

Hanberry, B.B.; Justice, D.C.; Powell, D.C. 2020. Discovering Douglas-Fir woodlands in the historical forests of Umatilla National Forest, eastern Oregon and Washington. Forests. 11(10): 1122 (20 p). doi:10.3390/f11101122

Hankin, L.E.; Higuera, P.E.; Davis, K.T.; Dobrowski, S.Z. 2018. Accuracy of node and bud-scar counts for aging two dominant conifers in western North America. Forest Ecology and Management. 427: 365-371. doi:10.1016/j.foreco.2018.06.001

Hankin, L.E.; Higuera, P.E.; Davis, K.T.; Dobrowski, S.Z. 2019. Impacts of growing-season climate on tree growth and post-fire regeneration in ponderosa pine and Douglas-fir forests. Ecosphere. 10(4): e02679 (20 p). doi:10.1002/ecs2.2679

Hann, D.W.; Brodie, J.D.; Ritters, K.H. 1983. Optimum stand prescriptions for ponderosa pine. Journal of Forestry. 81(9): 595-598. doi:10.1093/jof/81.9.595

Hannah, L.; Costello, C.; Guo, C.; Ries, L.; Kolstad, C.; Panitz, D.; Snider, N. 2011. The impact of climate change on California timberlands. Climatic Change. 109(Supplement 1): 429-443. doi:10.1007/s10584-011-0307-2

Hansen, A.J.; Spies, T.A.; Swanson, F.J.; Ohmann, J.L. 1991. Conserving biodiversity in managed forests. BioScience. 41(6): 382-392. doi:10.2307/1311745

Hanson, P.J.; Weltzin, J.F. 2000. Drought disturbance from climate change: response of United States forests. Science of the Total Environment. 262(3): 205-220. doi:10.1016/S0048-9697(00)00523-4

Hardy, C.C. 2005. Wildland fire hazard and risk: problems, definitions, and context. Forest Ecology and Management. 211(1-2): 73-82. doi:10.1016/j.foreco.2005.01.029

Hardy, C.C.; Arno, S.F. 1996. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station. 86 p. https://www.fs.usda.gov/treesearch/pubs/27534

Hardy, C.C.; Keane, R.E.; Harrington, M.G. 1999. Restoration of northwest interior forests. In: Transactions of the 64th North American wildlife and natural resources conference. Washington, DC: Wildlife Management Institute: 117-138.

Harmon, M.E.; Marks, B. 2002. Effects of silvicultural practices on carbon storage in Douglas-fir–western hemlock forests in the Pacific Northwest, U.S.A.: results from a simulation model. Canadian Journal of Forest Research. 32(5): 863-877. doi:10.1139/x01-216

Harmon, M.E.; Franklin, J.F.; Swanson, F.J.; Sollins, P.; Gregory, S.V.; Lattin, J.D.; Anderson, N.H.; Cline, S.P.; Aumen, N.G.; Sedell, J.R.; Lienkaemper, G.W.; Cromack, K., Jr.; Cummins, K.W. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research. 15: 133-302. doi:10.1016/S0065-2504(08)60121-X

Harrington, M.G. 1987. Ponderosa pine mortality from spring, summer, and fall crown scorching. Western Journal of Applied Forestry. 2(1): 14-16. doi:10.1093/wjaf/2.1.14

Harrington, M.G. 1993. Predicting *Pinus ponderosa* mortality from dormant season and growing season fire injury. International Journal of Wildland Fire. 3(2): 65-72. doi:10.1071/WF9930065

Harrington, M.G. 1996. Prescribed fire applications: Restoring ecological structure and process in ponderosa pine forests. In: Hardy, C.C.; Arno, S.F., eds. The use of fire in forest restoration. Gen. Tech. Rep. INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station: 41. https://www.fs.usda.gov/treesearch/pubs/28488

Harrington, M.G.; Kelsey, R.G. 1979. Influence of some environmental factors on initial establishment and growth of ponderosa pine seedlings. Res. Pap. INT-230. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 26 p. https://archive.org/download/influenceofsomee230harr/influenceofsomee230harr.pdf

Harris, R.W. 1954. Fluctuations in forage utilization on ponderosa pine ranges in eastern Oregon. Journal of Range Management. 7(6): 250-255. https://journals.uair.arizona.edu/index.php/jrm/article/download/4628/4239

Harris, G.R.; Covington, W.W. 1983. The effect of a prescribed fire on nutrient concentration and standing crop of understory vegetation in ponderosa pine. Canadian Journal of Forest Research. 13(3): 501-507. doi:10.1139/x83-074

Harris, R.M.; Clifton, C.F.; Wondzell, S.M. 2007. Hillslope erosion rates in areas with volcanic parent materials and the effects of prescribed fires in the Blue Mountains of eastern Oregon and Washington, USA. In: Furniss, M.; Clifton, C.; Ronnenberg, K. Advancing the fundamental sciences: proceedings of the Forest Service national earth sciences conference. Gen. Tech. Rep. PNW-GTR-689. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 7-19.

Harrod, R.J.; Gaines, W.L.; Hartl, W.E.; Camp, A. 1998. Estimating historical snag density in dry forests east of the Cascade Range. Gen. Tech. Rep. PNW-GTR-428. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 16 p. http://www.treesearch.fs.fed.us/pubs/3247

Harrod, R.J.; McRae, B.H.; Hartl, W.E. 1999. Historical stand reconstruction in ponderosa pine forests to guide silvicultural prescriptions. Forest Ecology and Management. 114(2-3): 433-446. doi:10.1016/S0378-1127(98)00373-9

Harrod, R.J.; Peterson, D.W.; Povak, N.A.; Dodson, E.K. 2009. Thinning and prescribed fire effects on overstory tree and snag structure in dry coniferous forests of the interior Pacific Northwest. Forest Ecology and Management. 258(5): 712-721. doi:10.1016/j.foreco.2009.05.011

Hart, S.C.; Firestone, M.K.; Paul, E.A. 1992. Decomposition and nutrient dynamics of ponderosa pine needles in a Mediterranean-type climate. Canadian Journal of Forest Research. 22(3):

306-314. doi:10.1139/x92-040

Hart, S.C.; Classen, A.T.; Wright, R.J. 2005. Long-term interval burning alters fine root and mycorrhizal dynamics in a ponderosa pine forest. Journal of Applied Ecology. 42(4): 752-761. doi:10.1111/j.1365-2664.2005.01055.x

Hartsough, B.R.; Abrams, S.; Barbour, R.J.; Drews, E.S.; McIver, J.D.; Moghaddas, J.J.; Schwilk, D.W.; Stephens, S.L. 2008. The economics of alternative fuel reduction treatments in western United States dry forests: financial and policy implications from the National Fire and Fire Surrogate Study. Forest Policy and Economics. 10(6): 344-354. doi:10.1016/j.forpol.2008.02.001

Hartter, J.; Stevens, F.R.; Hamilton, L.C.; Oester, P.T.; Congalton, R.G.; Ducey, M.J.; Crowley, M.A. 2014. Forest management and wildfire risk in inland Northwest: Survey of landowners' concerns about public land management in northeastern Oregon. National Issue Brief #70. Durham, NH: University of New Hampshire, Carsey Institute. 8 p. https://scholars.unh.edu/carsey/211/

Hartter, J.; Stevens, F.R.; Hamilton, L.C.; Congalton, R.G.; Ducey, M.J.; Oester, P.T. 2015. Modelling associations between public understanding, engagement and forest conditions in the Inland Northwest, USA. PLoS ONE. 10(2): e0117975. doi:10.1371/journal.pone.0117975

Hartter, J.; Hamilton, L.C.; Ducey, M.J.; Boag, A.E.; Christoffersen, N.D.; Belair, E.P.; Oester, P.T.; Palace, M.W.; Stevens, F.R. 2017. Drier conditions, more wildfire, and heightened concerns about forest management in eastern Oregon. National Issue Brief #127. Durham, NH: University of New Hampshire, Carsey School of Public Policy. 6 p. https://carsey.unh.edu/publication/forest-management-oregon

Hartter, J.; Hamilton, L.C.; Ducey, M.J.; Boag, A.E.; Salerno, J.D.; Christoffersen, N.D.; Oester, P.T.; Palace, M.W.; Stevens, F.R. 2020. Finding common ground: agreement on increasing wildfire risk crosses political lines. Environmental Research Letters. 15(6): 065002 (12 p). doi:10.1088/1748-9326/ab7ace

Harvey, A.E. 1994. Integrated roles for insects, diseases and decomposers in fire dominated forests of the inland western United States: past, present and future forest health. Journal of Sustainable Forestry. 2(1/2): 211-220. doi:10.1300/J091v02n01_10

Harvey, A.E.; Larsen, M.J.; Jurgensen, M.F. 1979. Fire – decay: interactive roles regulating wood accumulation and soil development in the northern Rocky Mountains. Res. Note INT-263. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 4 p. USDA_Forest_Service_Research_Note_INT

Harvey, A.E.; Jurgensen, M.F.; Graham, R.T. 1988. The role of woody residues in soils of ponderosa pine forests. In: Baumgartner, D.M.; Lotan, J.E., comps. Ponderosa pine: the species and its management; symposium proceedings. Pullman, WA: Washington State University, Depart. of Natural Resource Sciences, Cooperative Extension: 141-147.

Harvey, A.E.; McDonald, G.I.; Jurgensen, M.F.; Larsen, M.J. 1994. Microbes: driving forces for long-term ecological processes in the inland northwest's cedar-hemlock-white pine forests. In: Baumgartner, D.M.; Lotan, J.E.; Tonn, J.R., comps. Interior cedar-hemlock-white pine forests: ecology and management. Pullman, WA: Washington State University, Department of Natural Resource Sciences: 157-163.

Harvey, A.E.; Graham, R.T.; McDonald, G.I. 1999. Tree species composition change – soil organism interaction: potential effects on nutrient cycling and conservation in interior forests. In: Meurisse, R.T.; Ypsilantis, W.G.; Seybold, C., tech. eds. Proceedings: Pacific Northwest forest and rangeland soil organism symposium. Gen. Tech. Rep. PNW-GTR-461. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 137-145. http://www.treesearch.fs.fed.us/pubs/7603

Harvey, B.J.; Donato, D.C.; Romme, W.H.; Turner, M.G. 2013. Influence of recent bark beetle outbreak on fire severity and postfire tree regeneration in montane Douglas-fir forests. Ecology. 94(11): 2475-2486. doi:10.1890/13-0188.1

Harvey, B.J.; Andrus, R.A.; Anderson, S.C. 2019. Incorporating biophysical gradients and uncertainty into burn severity maps in a temperate fire-prone forested region. Ecosphere. 10(2): e02600 (20 p). doi:10.1002/ecs2.2600

Hatten, J.; Zabowski, D.; Scherer, G.; Dolan, E. 2005. A comparison of soil properties after contemporary wildfire and fire suppression. Forest Ecology and Management. 220(1-3): 227-241. doi:10.1016/j.foreco.2005.08.014

Hatten, J.A.; Zabowski, D.; Ogden, A.; Thies, W. 2008. Soil organic matter in a ponderosa pine forest with varying seasons and intervals of prescribed burn. Forest Ecology and Management. 255(7): 2555-2565. doi:10.1016/j.foreco.2008.01.016

Hatten, J.; Zabowski, D.; Ogden, A.; Theis, W.; Choi, B. 2012. Role of season and interval of prescribed burning on ponderosa pine growth in relation to soil inorganic N and P and moisture. Forest Ecology and Management. 269: 106-115. doi:10.1016/j.foreco.2011.12.036

Hatton, J.H. 1920. Live-stock grazing as a factor in fire protection on the national forests. Depart. Circ. 134. Washington, DC: U.S. Department of Agriculture. 11 p. Dept_Circular

Haufler, J.B. 1994. An ecological framework for planning for forest health. Journal of Sustainable Forestry. 2(3-4): 307-316. doi:10.1300/J091v02n03_06

Haufler, J. 2004. Fire, forest health, and birds in the Rockies. Bird Conservation: 12-13.

Haufler, J.B.; Mehl, C.A.; Roloff, G.J. 1996. Using a coarse-filter approach with species assessment for ecosystem management. Wildlife Society Bulletin. 24(2): 200-208. doi:10.2307/3783108

Haughian, S.R.; Burton, P.J.; Taylor, S.W.; Curry, C. 2012. Expected effects of climate change on forest disturbance regimes in British Columbia. BC Journal of Ecosystems and Management. 13(1): 1-24. http://jem.forrex.org/index.php/jem/article/view/152

Haugo, R.D.; Hall, S.A.; Gray, E.M.; Gonzalez, P.; Bakker, J.D. 2010. Influences of climate, fire, grazing, and logging on woody species composition along an elevation gradient in the eastern Cascades, Washington. Forest Ecology and Management. 260(12): 2204-2213. doi:10.1016/j.foreco.2010.09.021

Hawksworth, F.G.; Geils, B.W. 1985. Vertical spread of dwarf mistletoe in thinned ponderosa pine in Arizona. Res. Note RM-460. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p. https://archive.org/download/IND86027248/IND86027248.pdf

Hawksworth, F.G.; Geils, B.W. 1990. How long do mistletoe-infected ponderosa pines live? Western Journal of Applied Forestry. 5(2): 47-48. doi:10.1093/wjaf/5.2.47

Hayes, J.L.; Quigley, T.M.; Starr, L., guest eds. 2001. Forest health and productivity in eastern Oregon and Washington. Northwest Science. 75(special issue): 1-251. issn:0029-344X

Haynes, R.W.; Graham, R.T.; Quigley, T.M., tech. eds. 1996. A framework for ecosystem management in the interior Columbia Basin including portions of the Klamath and Great Basins.

Gen. Tech. Rep. PNW-GTR-374. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 68 p. http://www.treesearch.fs.fed.us/pubs/3060

Haynes, R.W.; Quigley, T.M.; Clifford, J.L.; Gravenmier, R.A. 2001. Science and ecosystem management in the interior Columbia basin. Forest Ecology and Management. 153(1-3): 3-14. doi:10.1016/S0378-1127(01)00450-9

Hedrick, D.W.; Young, J.A.; McArthur, J.A.B.; Keniston, R.F. 1968. Effects of forest and grazing practices on mixed coniferous forests of northeastern Oregon. Tech. Bull. 103. Corvallis, OR: Oregon State University, Agricultural Experiment Station. 24 p. https://ir.library.oregonstate.edu/downloads/wp988m05s

Heidmann, L.J. 1983. Silvicultural control of dwarf mistletoe in southwestern ponderosa pine. Res. Note RM-433. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/IND84043878/IND84043878.pdf

Heidmann, L.J. 1985. Heavy fertilization increases diameter growth slightly in a 55-year-old ponderosa pine stand in central Arizona. Res. Note RM-452. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p.

Heidmann, L.J.; Cornett, Z.J. 1986. Effect of various nutrient regimes and ectomycorrhizal inoculations on field survival and growth of ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engelm.) container seedlings in Arizona. Tree Planters' Notes. 37(3): 15-19. Tree Planters Notes

Heidmann, L.J.; King, R.M. 1992. Effect of prolonged drought on water relations of ponderosa seedlings growing in basalt and sedimentary soils. Res. Note RM-301. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p. https://archive.org/download/IND92036500/IND92036500.pdf

Heidmann, L.J.; Thorud, D.B. 1976. Controlling frost heaving of ponderosa pine seedlings in Arizona. Res. Pap. RM-172. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p. https://archive.org/download/CAT92273543/CAT92273543.pdf

Heidmann, L.J.; Larson, F.R.; Rietveld, W.J. 1977. Evaluation of ponderosa pine reforestation techniques in central Arizona. Res. Pap. RM-190. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 10 p. https://archive.org/download/CAT92273408/CAT92273408.pdf

Heidmann, L.J.; Johnsen, T.N., Jr.; Cole, Q.W.; Cullum, G. 1982. Establishing natural regeneration of ponderosa pine in central Arizona. Journal of Forestry. 80(2): 77-79. doi:10.1093/jof/80.2.77

Heidmann, L.J.; Ffolliott, P.F.; Gottfried, G.J. 1997. Thirty-year growth and yield of a ponderosa pine plantation in Arizona. Res. Note RM-RN-537. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 6 p. https://archive.org/download/IND20622356/IND20622356.pdf

Heil, L.J.; Burkle, L.A. 2019. The effects of post-wildfire salvage logging on plant reproductive success and pollination in *Symphoricarpos albus*, a fire-tolerant shrub. Forest Ecology and Management. 432: 157-163. doi:10.1016/j.foreco.2018.09.013

Heinselman, M.L. 1981. Fire intensity and frequency as factors in the distribution and structure of northern ecosystems. In: Mooney, H.A.; Bonnicksen, T.M.; Christensen, N.L.; Lotan, J.E.; Reiners, W.A., tech. coords. Fire regimes and ecosystem properties: proceedings of the conference. Gen. Tech. Rep. WO-26. Washington, DC: USDA Forest Service, Washington Office:

7-57. https://archive.org/download/CAT83781017/CAT83781017.pdf

Heintzleman, B.F. 1913. North slope sub-type of the Blue Mountains. Annual Silvical Rep. Sumpter, OR: USDA Forest Service, Whitman National Forest. Unpublished report obtained from National Archives, College Park, Maryland; record group 95. 10 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015535.pdf

Helms, J.A. 1972. Environmental control of net photosynthesis in naturally growing *Pinus ponderosa* Laws. Ecology. 53(1): 92-101. doi:10.2307/1935713

Helms, J.D. 1984. Walter Lowdermilk's journey: Forester to land conservationist. Environmental Review. 8(2): 133-145. doi:10.2307/3984191

Helmers, A.E. 1946. Results of direct seeding ponderosa pine. Res. Note No. 46. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 5 p. https://archive.org/download/CAT31013679/CAT31013679.pdf

Hemstrom, M.A. 2001. Vegetative patterns, disturbances, and forest health in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 91-109. http://hdl.handle.net/2376/986

Hendrickson, O.Q.; Burgess, D. 1989. Nitrogen-fixing plants in a cut-over lodgepole pine stand of southern British Columbia. Canadian Journal of Forest Research. 19(7): 936-939. doi:10.1139/x89-143

Henjum, M.G.; Karr, J.R.; Bottom D.L.; Perry, D.A.; Bednarz, J.C.; Wright, S.G.; Beckwitt, S.A.; Beckwitt, E. 1994. Interim protection for late-successional forests, fisheries, and watersheds; national forests east of the Cascade crest, Oregon, and Washington. The Wildlife Society Tech. Rev. 94-2. Bethesda, MD: The Wildlife Society. 245 p.

Hermann, R.K.; Chilcote, W.W. 1965. Effect of seedbeds on germination and survival of Douglas-fir. Research Paper 4. Corvallis, OR: Oregon State University, Forest Research Laboratory. 30 p. https://ir.library.oregonstate.edu/concern/technical_reports/qb98mg772

Hermann, R.K.; Lavender, D.P. 1990. *Pseudotsuga menziesii* (Mirb.) Franco; Douglas-fir. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America; volume 1, conifers. Agricul. Handb. 654. Washington, DC: USDA Forest Service: 527-540. https://www.treesearch.fs.fed.us/pubs/1547

Hermann, R.K.; Petersen, R.G. 1969. Root development and height increment of ponderosa pines in pumice soils of central Oregon. Forest Science. 15(3): 226-237. doi:10.1093/forestscience/15.3.226

Hessburg, P.F.; Agee, J.K. 2003. An environmental narrative of Inland Northwest United States forests, 1800-2000. Forest Ecology and Management. 178(1-2): 23-59. doi:10.1016/S0378-1127(03)00052-5

Hessburg, P.F.; Mitchell, R.G.; Filip, G.M. 1994. Historical and current roles of insects and pathogens in eastern Oregon and Washington forested landscapes. Gen. Tech. Rep. PNW-GTR-327. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 72 p. http://www.treesearch.fs.fed.us/pubs/6390

Hessburg, P.F.; Smith, B.G.; Kreiter, S.D.; Miller, C.A.; Salter, R.B.; McNicholl, C.H.; Hann, W.J. 1999a. Historical and current forest and range landscapes in the interior Columbia River basin and portions of the Klamath and Great basins. Part 1: linking vegetation patterns and landscape vulnerability to potential insect and pathogen disturbances. Gen. Tech. Rep. PNW-GTR-458. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 357 p. http://www.treesearch.fs.fed.us/pubs/29638

Hessburg, P.F.; Smith, B.G; Salter, R.B. 1999b. Detecting change in forest spatial patterns from reference conditions. Ecological Applications. 9(4): 1232-1252. doi:10.1890/1051-0761(1999)009[1232:DCIFSP]2.0.CO;2

Hessburg, P.F.; Smith, B.G.; Salter, R.B. 1999c. Using estimates of natural variation to detect ecologically important change in forest spatial patterns: a case study, Cascade Range, eastern Washington. Res. Pap. PNW-RP-514. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 65 p. https://www.fs.usda.gov/treesearch/pubs/2910

Hessburg, P.F.; Smith, B.G.; Salter, R.B.; Ottmar, R.D.; Alvarado, E. 2000. Recent changes (1930s-1990s) in spatial patterns of interior northwest forests, USA. Forest Ecology and Management. 136(1-3): 53-83. doi:10.1016/S0378-1127(99)00263-7

Hessburg, P.F.; Reynolds, K.M.; Salter, R.B.; Richmond, M.B. 2004. Using a decision support system to estimate departures of present forest landscape patterns from historical reference conditions. In: Perera, A.H.; Buse, L.J.; Weber, M.G., eds. Emulating natural forest landscape disturbances: concepts and applications. New York: Columbia University Press: 158-175. isbn:0-231-12916-5

Hessburg, P.F.; Agee, J.K.; Franklin, J.F. 2005. Dry forests and wildland fires of the inland Northwest USA: contrasting the landscape ecology of the pre-settlement and modern eras. Forest Ecology and Management. 211(1-2): 117-139. doi:10.1016/j.foreco.2005.02.016

Hessburg, P.; Salter, R.; James, K. 2007. Re-examining fire severity relations in pre-management era mixed conifer forests: inferences from landscape patterns of forest structure. Landscape Ecology. 22(Supplement 1): 5-24. doi:10.1007/s10980-007-9098-2

Hessburg, P.F.; Povak, N.A.; Salter, R.B. 2008. Thinning and prescribed fire effects on dwarf mistletoe severity in an eastern Cascade Range dry forest, Washington. Forest Ecology and Management. 255(7): 2907-2915. doi:10.1016/j.foreco.2008.01.066

Hessburg, P.F.; Povak, N.A.; Salter, R.B. 2010. Thinning and prescribed fire effects on snag abundance and spatial pattern in an eastern Cascade Range dry forest, Washington, USA. Forest Science. 56(1): 74-87. doi:10.1093/forestscience/56.1.74

Hessburg, P.; Reynolds, K.; Salter, R.; Dickinson, J.; Gaines, W.; Harrod, R. 2013. Landscape evaluation for restoration planning on the Okanogan-Wenatchee National Forest, USA. Sustainability. 5(3): 805-840. doi:10.3390/su5030805

Hessburg, P.F.; Churchill, D.J.; Larson, A.J.; Haugo, R.D.; Miller, C.; Spies, T.A.; North, M.P.; Povak, N.A.; Belote, R.T.; Singleton, P.H.; Gaines, W.L.; Keane, R.E.; Aplet, G.H.; Stephens, S.L.; Morgan, P.; Bisson, P.A.; Rieman, B.E.; Salter, R.B.; Reeves, G.H. 2015. Restoring fire-prone Inland Pacific landscapes: seven core principles. Landscape Ecology. 30(10): 1805-1835. doi:10.1007/s10980-015-0218-0

Hessburg, P.F.; Spies, T.A.; Perry, D.A.; Skinner, C.N.; Taylor, A.H.; Brown, P.M.; Stephens, S.L.; Larson, A.J.; Churchill, D.J.; Povak, N.A.; Singleton, P.H.; McComb, B.; Zielinski, W.J.; Collins, B.M.; Salter, R.B.; Keane, J.J.; Franklin, J.F.; Riegel, G. 2016. Tamm review: Management of mixed-severity fire regime forests in Oregon, Washington, and northern California. Forest Ecology and Management. 366: 221-250. doi:10.1016/j.foreco.2016.01.034

Hessburg, P.F.; Miller, C.L.; Parks, S.A.; Povak, N.A.; Taylor, A.H.; Higuera, P.E.; Prichard, S.J.; North, M.P.; Collins, B.M.; Hurteau, M.D.; Larson, A.J.; Allen, C.D.; Stephens, S.L.; Rivera-Huerta, H.; Stevens-Rumann, C.S.; Daniels, L.D.; Gedalof, Z.e.; Gray, R.W.; Kane, V.R.; Churchill, D.J.; Hagmann, R.K.; Spies, T.A.; Cansler, C.A.; Belote, R.T.; Veblen, T.T.;

Battaglia, M.A.; Hoffman, C.; Skinner, C.N.; Safford, H.D.; Salter, R.B. 2019. Climate, environment, and disturbance history govern resilience of western North American forests. Frontiers in Ecology and Evolution. 7: 239 (27 p). doi:10.3389/fevo.2019.00239

Hessburg, P.F.; Charnley, S.; Wendel, K.L.; White, E.M.; Singleton, P.H.; Peterson, D.W.; Halofsky, J.E.; Gray, A.N.; Spies, T.A.; Flitcroft, R.L.; White, R. 2020. The 1994 Eastside Screens large-tree harvest limit: review of science relevant to forest planning 25 years later. Gen. Tech. Rep. PNW-GTR-990. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 114 p. https://www.fs.usda.gov/treesearch/pubs/60635

Hessl, A.; Spackman, S. 1995. Effects of fire on threatened and endangered plants: an annotated bibliography. Information and Technology Rep. 2. Washington, DC: U.S. Department of the Interior, National Biological Service. 51 p. https://www.nwrc.usgs.gov/wdb/pub/others/1995_02.pdf

Hessl, A.E.; McKenzie, D.; Schellhaas, R. 2004. Drought and Pacific Decadal Oscillation linked to fire occurrence in the inland Pacific Northwest. Ecological Applications. 14(2): 425-442. doi:10.1890/03-5019

Heyerdahl, E.K. 1997. Spatial and temporal variation in historical fire regimes of the Blue Mountains, Oregon and Washington: the influence of climate. Ph.D. dissertation. Seattle, WA: University of Washington, College of Forest Resources. 224 p. http://hdl.handle.net/1773/5575

Heyerdahl, E.K.; Agee, J.K. 1996. Historical fire regimes of four sites in the Blue Mountains, Oregon and Washington. Final Rep. Seattle, WA: University of Washington, College of Forest Resources. 173 p.

Heyerdahl, E.K.; Brubaker, L.B.; Agee, J.K. 2001. Spatial controls of historical fire regimes: a multiscale example from the interior west, USA. Ecology. 82(3): 660-678. doi:10.1890/0012-9658(2001)082[0660:SCOHFR]2.0.CO;2

Heyerdahl, E.K.; Brubaker, L.B.; Agee, J.K. 2002. Annual and decadal climate forcing of historical fire regimes in the interior Pacific Northwest, USA. Holocene. 12(5): 597-604. doi:10.1191/0959683602hl570rp

Heyerdahl, E.K.; McKenzie, D.; Daniels, L.D.; Hessl, A.E.; Littell, J.S.; Mantua, N.J. 2008a. Climate drivers of regionally synchronous fires in the inland Northwest (1651-1900). International Journal of Wildland Fire. 17(1): 40-49. doi:10.1071/WF07024

Heyerdahl, E.K.; Morgan, P.; Riser, J.P. 2008b. Crossdated fire histories (1650 to 1900) from ponderosa pine-dominated forests of Idaho and western Montana. Gen. Tech. Rep. RMRS-GTR-214WWW. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 83 p. http://www.treesearch.fs.fed.us/pubs/30722

Heyerdahl, E.K.; Morgan, P.; Riser, J.P. 2008c. Multi-season climate synchronized historical fires in dry forests (1650-1900), northern Rockies, USA. Ecology. 89(3): 705-716. doi:10.1890/06-2047.1

Heyerdahl, E.K.; Lertzman, K.; Wong, C.M. 2012. Mixed-severity fire regimes in dry forests of southern interior British Columbia, Canada. Canadian Journal of Forest Research. 42(1): 88-98. doi:10.1139/x11-160

Heyerdahl, E.K.; Loehman, R.A.; Falk, D.A. 2018. A multi-century history of fire regimes along a transect of mixed-conifer forests in central Oregon, U.S.A. Canadian Journal of Forest Research. 49(1): 76-86. doi:10.1139/cjfr-2018-0193

Hicke, J.A.; Xu, B.; Meddens, A.J.H.; Egan, J.M. 2020. Characterizing recent bark beetle-caused tree mortality in the western United States from aerial surveys. Forest Ecology and Management. 475: 118402 (13 p). doi:10.1016/j.foreco.2020.118402

Hiers, J.K.; Laine, S.C.; Bachant, J.J.; Furman, J.H.; Greene, W.W., Jr.; Compton, V. 2003. Simple spatial modeling tool for prioritizing prescribed burning activities at the landscape scale. Conservation Biology. 17(6): 1571-1578. doi:10.1111/j.1523-1739.2003.00381.x

Hildman, A.T. 1940. Cutting practices in the ponderosa pine region of the Northwest. Journal of Forestry. 38(9): 692-695. doi:10.1093/jof/38.9.692

Hill, R.R. 1917. Effects of grazing upon western yellow-pine reproduction in the national forests of Arizona and New Mexico. Bull. No. 580. Washington, DC: U.S. Department of Agriculture. 27 p. https://archive.org/download/effectsofgrazing580hill/effectsofgrazing580hill.pdf

Hill, E.M.; Ex, S. 2020. Microsite conditions in a low-elevation Engelmann spruce forest favor ponderosa pine establishment during drought conditions. Forest Ecology and Management. 463: 118037. doi:10.1016/j.foreco.2020.118037

Hjerpe, E.; Kim, Y.-S.; Dunn, L. 2016. Forest density preferences of homebuyers in the wildland-urban interface. Forest Policy and Economics. 70: 56-66. doi:10.1016/j.forpol.2016.05.012

Hollenbeck, J.P.; Ripple, W.J. 2007. Aspen and conifer heterogeneity effects on bird diversity in the northern Yellowstone ecosystem. Western North American Naturalist. 67(1): 92-101. doi:10.3398/1527-0904(2007)67[92:AACHEO]2.0.CO;2

Hollenbeck, J.P.; Bate, L.J.; Saab, V.A.; Lehmkuhl, J.F. 2013. Snag distributions in relation to human access in ponderosa pine forests. Wildlife Society Bulletin. 37(2): 256-266. doi:10.1002/wsb.252

Holling, C.S.; Meffe, G.K. 1996. Command and control and the pathology of natural resource management. Conservation Biology. 10(2): 328-337. doi:10.1046/j.1523-1739.1996.10020328.x

Holtby, B.E. 1947. Soil texture as a site indicator in the ponderosa pine stands of southeastern Washington. Journal of Forestry. 45(11): 824-825. doi:10.1093/jof/45.11.824

Hood, S.M. 2010. Mitigating old tree mortality in long-unburned, fire-dependent forests: a synthesis. Gen. Tech. Rep. RMRS-GTR-238. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 71 p. http://www.treesearch.fs.fed.us/pubs/35004

Hood, S.M.; Cluck, D.R.; Jones, B.E.; Pinnell, S. 2017. Radial and stand-level thinning treatments: 15-year growth response of legacy ponderosa and Jeffrey pine trees. Restoration Ecology. doi:10.1111/rec.12638

Hoover, C.M.; Bush, R.; Palmer, M.; Treasure, E. 2020. Using Forest Inventory and Analysis data to support national forest management: Regional case studies. Journal of Forestry. 118(3): 313-323. doi:10.1093/jofore/fvz073

Hopkins, T.; Larson, A.J.; Belote, R.T. 2014. Contrasting effects of wildfire and ecological restoration in old-growth western larch forests. Forest Science. 60(5): 1005-1013. doi:10.5849/forsci.13-088

Hornibrook, E.M. 1939. Preliminary yield tables for selectively cut stands of ponderosa pine in the Black Hills. Journal of Forestry. 37(10): 807-812. doi:10.1093/jof/37.10.807

Howard, J.L.; Aleksoff, K.C. 2000. *Abies grandis*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). https://www.fs.fed.us /database/feis/plants/tree/abigra/all.html

Howe, A.A.; Landhäusser, S.M.; Burney, O.T.; Long, J.N.; Violett, R.D.; Mock, K.E. 2020. Exploring seedling-based aspen (*Populus tremuloides*) restoration near range limits in the Intermountain West, USA. Forest Ecology and Management. 476: 118470 (10 p). doi:10.1016/j.foreco.2020.118470

Hubbard, W.F. 1904. Forest thinning and its results. Part I. Forestry and Irrigation. 10(6): 268-271. Hubbard 1904

Hubbard, W.F. 1904. Forest thinning and its results. Part II–The result of thinning. Forestry and Irrigation. 10(7): 313-319.

Huber-Stearns, H.; Santo, A. 2018. Restoring resilience at the landscape scale: Lessons learned from the Blue Mountains Restoration Strategy Team. Working Paper 89. Eugene, OR: University of Oregon, Ecosystem Workforce Program. 14 p. http://hdl.handle.net/1794/24163

Huckaby, L.S.; Kaufmann, M.R.; Fornwalt, P.J.; Stoker, J.M.; Dennis, C. 2003. Identification and ecology of old ponderosa pine trees in the Colorado Front Range. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 47 p. https://www.fs.usda.gov/treesearch/pubs/5576

Hudler, G.W.; Oshima, N.; Hawksworth, F.G. 1979. Bird dissemination of dwarf mistletoe on ponderosa pine in Colorado. American Midland Naturalist. 102(2): 273-280. doi:10.2307/2424654

Huffman, D.W.; Sánchez Meador, A.J.; Stoddard, M.T.; Crouse, J.E.; Roccaforte, J.P. 2017. Efficacy of resource objective wildfires for restoration of ponderosa pine (*Pinus ponderosa*) forests in northern Arizona. Forest Ecology and Management. 389(Supplement C): 395-403. doi:10.1016/j.foreco.2016.12.036

Huffman, D.W.; Crouse, J.E.; Sánchez Meador, A.J.; Springer, J.D.; Stoddard, M.T. 2018. Restoration benefits of re-entry with resource objective wildfire on a ponderosa pine landscape in northern Arizona, USA. Forest Ecology and Management. 408: 16-24. doi:10.1016/j.foreco.2017.10.032

Huggett, R.J., Jr.; Abt, K.L.; Shepperd, W. 2008. Efficacy of mechanical fuel treatments for reducing wildfire hazard. Forest Policy and Economics. 10(6): 408-414. doi:10.1016/j.forpol.2008.03.003

Hull, A.C., Jr.; Johnson, W.M. 1955. Range seeding in the ponderosa pine zone in Colorado. Circular No. 953. Washington, DC: U.S. Department of Agriculture. 40 p. https://www.fs.usda.gov/treesearch/pubs/59448

Hull, I.T.; Shipley, L.A.; Berry, S.L.; Loggers, C.; Johnson, T.R. 2020. Effects of fuel reduction timber harvests on forage resources for deer in northeastern Washington. Forest Ecology and Management. 458: 117757 (13 p). doi:10.1016/j.foreco.2019.117757

Humphrey, R.R. 1943. A history of range use and its relation to soil and water losses on the Walla Walla River watershed, Washington and Oregon. Northwest Science. 17: 82-87.

Hunter, M.L., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Englewood Cliffs, NJ: Regents/Prentice Hall. 370 p. isbn:0-13-959479-5

Hunter, M.L., ed. 1999. Maintaining biodiversity in forest ecosystems. Cambridge, UK: Cambridge University Press. 550 p. isbn:0-521-63768-6

Hunter, M.E.; Robles, M.D. 2020. Tamm review: The effects of prescribed fire on wildfire regimes and impacts: A framework for comparison. Forest Ecology and Management. 475: 118435 (13 p). doi:10.1016/j.foreco.2020.118435

Hunter, M.E.; Shepperd, W.D.; Lentile, L.B.; Lundquist, J.E.; Andreu, M.G.; Butler, J.L.; Smith, F.W. 2007. A comprehensive guide to fuels treatment practices for ponderosa pine in the Black Hills, Colorado Front Range, and southwest. Gen. Tech. Rep. RMRS-GTR-198. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 93 p. http://www.treesearch.fs.fed.us/pubs/28477

Hunter, M.E.; Iniguez, J.M.; Lentile, L.B. 2011. Short- and long-term effects on fuels, forest structure, and wildfire potential from prescribed fire and resource benefit fire in southwestern forests, USA. Fire Ecology. 7(3): 108-121. doi:10.4996/fireecology.0703108

Huntzinger, M. 2003. Effects of fire management practices on butterfly diversity in the forested western United States. Biological Conservation. 113(1): 1-12. doi:10.1016/S0006-3207(02)00356-7

Hurteau, M.D.; Brooks, M.L. 2011. Short- and long-term effects of fire on carbon in US dry temperate forest systems. BioScience. 61(2): 139-146. doi:10.1525/bio.2011.61.2.9

Hurteau, M.; North, M. 2008. Mixed-conifer understory response to climate change, nitrogen, and fire. Global Change Biology. 14(7): 1543-1552. doi:10.1111/j.1365-2486.2008.01584.x

Hurteau, M.D.; North, M. 2010. Carbon recovery rates following different wildfire risk mitigation treatments. Forest Ecology and Management. 260(5): 930-937. doi:10.1016/j.foreco.2010.06.015

Hurteau, M.D.; Koch, G.W.; Hungate, B.A. 2008a. Carbon protection and fire risk reduction: toward a full accounting of forest carbon offsets. Frontiers in Ecology and the Environment. 6(9): 493-498. doi:10.1890/070187

Hurteau, S.R.; Sisk, T.D.; Block, W.M.; Dickson, B.G. 2008b. Fuel-reduction treatment effects on avian community structure and diversity. Journal of Wildlife Management. 72(5): 1168-1174. doi:10.2193/2007-351

Hurteau, M.D.; Stoddard, M.T.; Fulé, P.Z. 2011. The carbon costs of mitigating high-severity wildfire in southwestern ponderosa pine. Global Change Biology. 17(4): 1516-1521. doi:10.1111/j.1365-2486.2010.02295.x

Hurteau, M.D.; Liang, S.; Martin, K.L.; North, M.P.; Koch, G.W.; Hungate, B.A. 2016. Restoring forest structure and process stabilizes forest carbon in wildfire-prone southwestern ponderosa pine forests. Ecological Applications. 26(2): 382-391. doi:10.1890/15-0337

Hutto, R.L. 2008. The ecological importance of severe wildfires: some like it hot. Ecological Applications. 18(8): 1827-1834. doi:10.1890/08-0895.1

Innes, J.C.; North, M.P.; Williamson, N. 2006. Effect of thinning and prescribed fire restoration treatments on woody debris and snag dynamics in a Sierran old-growth, mixed-conifer forest. Canadian Journal of Forest Research. 36(12): 3183-3193. doi:10.1139/x06-184

Ireland, K.B.; Stan, A.B.; Fulé, P.Z. 2012. Bottom-up control of a northern Arizona ponderosa pine forest fire regime in a fragmented landscape. Landscape Ecology. 27(7): 983-997. doi:10.1007/s10980-012-9753-0

Irvine, J.; Law, B.E.; Hibbard, K.A. 2007. Postfire carbon pools and fluxes in semiarid ponderosa pine in central Oregon. Global Change Biology. 13(8): 1748-1760. doi:10.1111/j.1365-2486.2007.01368.x

Irvine, J.; Law, B.E.; Martin, J.G.; Vickers, D. 2008. Interannual variation in soil CO2 efflux and the response of root respiration to climate and canopy gas exchange in mature ponderosa pine. Global Change Biology. 14(12): 2848-2859. doi:10.1111/j.1365-2486.2008.01682.x

Irving, W. 1837. The adventures of Captain Bonneville, U.S.A, in the Rocky Mountains and the far West. 357 p. [Reprinted in 2001 by Binfords and Mort Publishers, Portland, OR.]

Irwin, L.L.; Cook, J.G.; Riggs, R.A.; Skovlin, J.M. 1994. Effects of long-term grazing by big game and livestock in the Blue Mountains forest ecosystems. Gen. Tech. Rep. PNW-GTR-325. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 49 p. https://www.fs.usda.gov/treesearch/pubs/6330

Irwin, L.L.; Riggs, R.A.; Verschuyl, J.P. 2018. Reconciling wildlife conservation to forest restoration in moist mixed-conifer forests of the inland northwest: A synthesis. Forest Ecology and Management. 424: 288-311. doi:10.1016/j.foreco.2018.05.007

Isaac, L.A. 1938. Factors affecting establishment of Douglas fir seedlings. Circular No. 486. Washington, DC: U.S. Department of Agriculture. 46 p. Factors_Affecting_Establishment_of_Dougl

Jackson, S.T.; Hobbs, R.J. 2009. Ecological restoration in the light of ecological history. Science. 325(5940): 567-569. doi:10.1126/science.1172977

Jaenicke, A.J.; Foerster, M.H. 1915. The influence of a western yellow pine forest on the accumulation and melting of snow. Monthly Weather Review. 43(3): 115-126. doi:10.1175/1520-0493(1915)43<115:TIOAWY>2.0.CO;2

Jain, T.B.; Battaglia, M.A.; Han, H.-S.; Graham, R.T.; Keyes, C.R.; Fried, J.; Sandquist, J.E. 2012. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States. Gen. Tech. Rep. RMRS-GTR-292. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 331 p. http://www.treesearch.fs.fed.us/pubs/42150

Jain, T.; Sikkink, P.; Keefe, R.; Byrne, J. 2018. To masticate or not: Useful tips for treating forest, woodland, and shrubland vegetation. Gen. Tech. Rep. RMRS-GTR-381. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 55 p. https://www.fs.usda.gov/treesearch/pubs/57328

Jaindl, R.G.; Quigley, T.M. 1995. Search for a solution: sustaining the land, people, and economy of the Blue Mountains. Washington, DC: American Forests. 316 p. ASIN: B0030H52BC

James, J.N.; Kates, N.; Kuhn, C.D.; Littlefield, C.E.; Miller, C.W.; Bakker, J.D.; Butman, D.E.; Haugo, R.D. 2018. The effects of forest restoration on ecosystem carbon in western North America: A systematic review. Forest Ecology and Management. 429: 625-641. doi:10.1016/j.foreco.2018.07.029

Jameson, D.A. 1968. Species interactions of growth inhibitors in native plants of northern Arizona. Res. Note RM-113. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p. Species_Interactions_of_Growth_Inhibitor

Jang, W.; Crotteau, J.S.; Ortega, Y.K.; Hood, S.M.; Keyes, C.R.; Pearson, D.E.; Lutes, D.C.; Sala, A. 2021. Native and non-native understory vegetation responses to restoration treatments in a dry conifer forest over 23 years. Forest Ecology and Management. 481: 118684. doi:10.1016/j.foreco.2020.118684

Jardine, J.T.; Anderson, M. 1919. Range management on the national forests. Bull. No. 790. Washington, DC: U.S. Department of Agriculture. 98 p. https://archive.org/download/rangemanagemento790jard/rangemanagemento790jard.pdf

Jemison, G.M. 1934. The significance of the effect of stand density upon the weather beneath the canopy. Journal of Forestry. 32(4): 446-451. doi:10.1093/jof/32.4.446

Jenkins, S.E.; Sieg, C.H.; Anderson, D.E.; Kaufman, D.S.; Pearthree, P.A. 2011. Late Holocene geomorphic record of fire in ponderosa pine and mixed-conifer forests, Kendrick Mountain, northern Arizona, USA. International Journal of Wildland Fire. 20(1): 125-141. doi:10.1071/WF09093

Jennings, M.; Loucks, O.; Peet, R.; Faber-Langendoen, D.; Glenn-Lewin, D.; Grossman, D.; Damman, A.; Barbour, M.; Pfister, R.; Walker, M.; Talbot, S.; Walker, J.; Hartshorn, G.; Waggoner, G.; Abrams, M.; Hill, A.; Roberts, D.; Tart, D.; Rejmanek, M. 2003. Guidelines for describing associations and alliances of the U.S. national vegetation classification; version 3 (November 25, 2003). Washington, DC: Ecological Society of America. 152 p.

Jennings, M.D.; Faber-Langendoen, D.; Loucks, O.L.; Peet, R.K.; Roberts, D. 2009. Standards for associations and alliances of the U.S. National Vegetation Classification. Ecological Monographs. 79(2): 173-199. doi:10.1890/07-1804.1

Jeronimo, S.M.A.; Kane, V.R.; Churchill, D.J.; Lutz, J.A.; North, M.P.; Asner, G.P.; Franklin, J.F. 2019. Forest structure and pattern vary by climate and landform across active-fire landscapes in the montane Sierra Nevada. Forest Ecology and Management. 437: 70-86. doi:10.1016/j.foreco.2019.01.033

Johnson, P.C. 1966. Some causes of natural tree mortality in old-growth ponderosa pine stands in western Montana. Res. Note INT-51. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 4 p. Some causes of natural tree mortality

Johnson, P.C. 1972. Bark beetle risk in mature ponderosa pine forests in western Montana. Res. Pap. INT-119. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 32 p. https://archive.org/download/barkbeetleriskin119john/barkbeetleriskin119john.pdf

Johnson, C.G., Jr. 1994. Forest health in the Blue Mountains: a plant ecologist's perspective on ecosystem processes and biological diversity. Gen. Tech. Rep. PNW-GTR-339. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 24 p. http://www.treesearch.fs.fed.us/pubs/5104

Johnson, C.G., Jr. 1998. Vegetation response after wildfires in national forests of northeastern Oregon. Tech. Pub. R6-NR-ECOL-TP-06-98. Portland, OR: USDA Forest Service, Pacific Northwest Region. 155 p. http://ecoshare.info/uploads/publications/VegetationResponseWFNFNEOrg.pdf

Johnson, C.G., Jr. 2004. Alpine and subalpine vegetation of the Wallowa, Seven Devils and Blue Mountains. Tech. Publ. R6-NR-ECOL-TP-03-04. Portland, OR: USDA Forest Service, Pacific Northwest Region. 612 p. http://ecoshare.info/uploads/publications/AlpineVegCompleteBook.pdf

Johnson, D.R.; Chance, D.H. 1974. Presettlement overharvest of upper Columbia River beaver populations. Canadian Journal of Zoology. 52(12): 1519-1521. doi:10.1139/z74-195

Johnson, C.G., Jr.; Clausnitzer, R.R. 1992. Plant associations of the Blue and Ochoco Mountains. Tech. Pub. R6-ERW-TP-036-92. Portland, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 164 p. Plant-Associations-of-the-Blue-and-Ochoco-Mountains

Johnson, D.W.; Hawksworth, F.G. 1988. Reduction of ponderosa pine dwarf mistletoe with the plant growth regulator ethephon. Tech. Report R2-42. Lakewood, CO: USDA Forest Service, Rocky Mountain Region, Timber, Forest Pest, and Cooperative Forest Management. 10 p. https://archive.org/download/IND88063700/IND88063700.pdf

Johnson, E.A.; Miyanishi, K. 1995. The need for consideration of fire behavior and effects in prescribed burning. Restoration Ecology. 3(4): 271-278. doi:10.1111/j.1526-100X.1995.tb00094.x

Johnson, M.C.; Peterson, D.L. 2005. Forest fuel treatments in western North America: merging silviculture and fire management. Forestry Chronicle. 81(3): 365-368. doi:10.5558/tfc81365-3

Johnson, C.G., Jr.; Simon, S.A. 1987. Plant associations of the Wallowa-Snake province. Tech. Publ. R6-ECOL-TP-225b-86. Baker City, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 272 p. http://ecoshare.info/2011/11/03/plant-associations-of-the-wallowa-snake-province/

Johnson, C.G., Jr.; Swanson, D.K. 2005. Bunchgrass plant communities of the Blue and Ochoco Mountains: a guide for managers. Gen. Tech. Rep. PNW-GTR-641. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 119 p. http://www.treesearch.fs.fed.us/pubs/20801

Johnson, C.G., Jr.; Clausnitzer, R.R.; Mehringer, P.J.; Oliver, C.D. 1994. Biotic and abiotic processes of eastside ecosystems: the effects of management on plant and community ecology, and on stand and landscape vegetation dynamics. Gen. Tech. Rep. PNW-GTR-322. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 66 p. http://www.treesearch.fs.fed.us/pubs/6252

Johnson, K.N.; Agee, J.; Beschta, R.; Beuter, J.; Gregory, S.; Kellogg, L.; McComb, W.; Sedell, J.; Schowalter, T.; Tesch, S. 1995. Forest health and timber harvest on national forests in the Blue Mountains of Oregon: a report to Governor Kitzhaber. Corvallis, OR: Oregon State University, College of Forestry. 51 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015662.pdf

Johnson, D.W.; Susfalk, R.B.; Dahlgren, R.A.; Klopatek, J.M. 1998. Fire is more important than water for nitrogen fluxes in semi-arid forests. Environmental Science and Policy. 1(2): 79-86. doi:10.1016/S1462-9011(98)00008-2

Johnson, D.W.; Murphy, J.F.; Susfalk, R.B.; Caldwell, T.G.; Miller, W.W.; Walker, R.F.; Powers, R.F. 2005. The effects of wildfire, salvage logging, and post-fire N-fixation on the nutrient budgets of a Sierran forest. Forest Ecology and Management. 220(1-3): 155-165. doi:10.1016/j.foreco.2005.08.011

Johnson, M.C.; Peterson, D.L.; Raymond, C.L. 2007. Guide to fuel treatments in dry forests of the western United States: assessing forest structure and fire hazard. Gen. Tech. Rep. PNW-GTR-686. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 322 p. http://www.treesearch.fs.fed.us/pubs/27293

Johnson, M.C.; Kennedy, M.C.; Peterson, D.L. 2011. Simulating fuel treatment effects in dry forests of the western United States: testing the principles of a fire-safe forest. Canadian Journal of Forest Research. 41(5): 1018-1030. doi:10.1139/x11-032

Johnston, V.R. 1970. The ecology of fire. Audubon. 72: 76-119.

Johnston, J.D. 2017. Forest succession along a productivity gradient following fire exclusion. Forest Ecology and Management. 392: 45-57. doi:10.1016/j.foreco.2017.02.050

Johnston, J.D.; Bailey, J.D.; Dunn, C.J. 2016. Influence of fire disturbance and biophysical heterogeneity on pre-settlement ponderosa pine and mixed conifer forests. Ecosphere. 7(11): e01581 (19 p). doi:10.1002/ecs2.1581

Johnston, J.D.; Bailey, J.D.; Dunn, C.J.; Lindsay, A.A. 2017. Historical fire-climate relationships in contrasting interior Pacific Northwest forest types. Fire Ecology. 13(2): 18-36. doi:10.4996/fireecology.130257453

Johnston, J.D.; Dunn, C.J.; Vernon, M.J.; Bailey, J.D.; Morrissette, B.A.; Morici, K.E. 2018. Restoring historical forest conditions in a diverse inland Pacific Northwest landscape. Ecosphere. 9(8): e02400 (23 p). doi:10.1002/ecs2.2400

Johnstone, J.F.; Allen, C.D.; Franklin, J.F.; Frelich, L.E.; Harvey, B.J.; Higuera, P.E.; Mack, M.C.; Meentemeyer, R.K.; Metz, M.R.; Perry, G.L.W.; Schoennagel, T.; Turner, M.G. 2016. Changing disturbance regimes, ecological memory, and forest resilience. Frontiers in Ecology and the Environment. 14(7): 369-378. doi:10.1002/fee.1311

Jones, K.W.; Cannon, J.B.; Saavedra, F.A.; Kampf, S.K.; Addington, R.N.; Cheng, A.S.; MacDonald, L.H.; Wilson, C.; Wolk, B. 2017. Return on investment from fuel treatments to reduce severe wildfire and erosion in a watershed investment program in Colorado. Journal of Environmental Management. 198(Part 2): 66-77. doi:10.1016/j.jenvman.2017.05.023

Josefsson, T.; Sutherland, E.K.; Arno, S.F.; Östlund, L. 2012. Ancient barkpeeled trees in the Bitterroot Mountains, Montana: Legacies of native land use and implications for their protection. Natural Areas Journal. 32(1): 54-64. doi:10.3375/043.032.0107

Joslin, L. 2007. Ponderosa promise: a history of U.S. Forest Service research in central Oregon. Gen. Tech. Rep. PNW-GTR-711. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 121 p. https://www.fs.usda.gov/treesearch/pubs/28616

Joyce, L.A.; Blate, G.M.; Littell, J.S.; McNulty, S.G.; Millar, C.I.; Moser, S.C.; Neilson, R.P.; O'Halloran, K.; Peterson, D.L. 2008. National forests. In: Julius, S.H.; West, J.M., eds. Preliminary review of adaptation options for climate-sensitive ecosystems and resources. Washington, DC: U.S. Environmental Protection Agency: 3-1 to 3-127. https://www.fs.usda.gov/treesearch/pubs/30612

Joyce, L.; Blate, G.; McNulty, S.; Millar, C.; Moser, S.; Neilson, R.; Peterson, D. 2009. Managing for multiple resources under climate change: national forests. Environmental Management. 44(6): 1022-1032. doi:10.1007/s00267-009-9324-6

Kalabokidis, K.D.; Omi, P.N. 1998. Reduction of fire hazard through thinning/residue disposal in the urban interface. International Journal of Wildland Fire. 8(1): 29-35. doi:10.1071/WF998002

Kalabokidis, K.D.; Wakimoto, R.H. 1992. Prescribed burning in uneven-aged stand management of ponderosa pine/Douglas fir forests. Journal of Environmental Management. 34(3): 221-235. doi:10.1016/S0301-4797(05)80153-7

Kalies, E.L.; Rosenstock, S.S. 2013. Stand structure and breeding birds: Implications for restoring ponderosa pine forests. Journal of Wildlife Management. 77(6): 1157-1165. doi:10.1002/jwmg.577

Kalies, E.L.; Yocom Kent, L.L. 2016. Tamm Review: Are fuel treatments effective at achieving ecological and social objectives? A systematic review. Forest Ecology and Management. 375: 84-95. doi:10.1016/j.foreco.2016.05.021

Kalies, E.L.; Chambers, C.L.; Covington, W.W. 2010. Wildlife responses to thinning and burning treatments in southwestern conifer forests: A meta-analysis. Forest Ecology and Management. 259(3): 333-342. doi:10.1016/j.foreco.2009.10.024

Kane, J.M.; Kolb, T.E.; McMillin, J.D. 2014. Stand-scale tree mortality factors differ by site and species following drought in southwestern mixed conifer forests. Forest Ecology and Management. 330: 171-182. doi:10.1016/j.foreco.2014.06.042

Kane, V.R.; Lutz, J.A.; Alina Cansler, C.; Povak, N.A.; Churchill, D.J.; Smith, D.F.; Kane, J.T.; North, M.P. 2015. Water balance and topography predict fire and forest structure patterns. Forest Ecology and Management. 338: 1-13. doi:10.1016/j.foreco.2014.10.038

Kane, J.M.; Varner, J.M.; Metz, M.R.; van Mantgem, P.J. 2017. Characterizing interactions between fire and other disturbances and their impacts on tree mortality in western U.S. Forests. Forest Ecology and Management. 405: 188-199. doi:10.1016/j.foreco.2017.09.037

Kane, V.R.; Bartl-Geller, B.N.; North, M.P.; Kane, J.T.; Lydersen, J.M.; Jeronimo, S.M.A.; Collins, B.M.; Monika Moskal, L. 2019. First-entry wildfires can create opening and tree clump patterns characteristic of resilient forests. Forest Ecology and Management. 454: 117659. doi:10.1016/j.foreco.2019.117659

Kangas, M.; Filip, G.M.; Morrell, J.J. 2009. Effect of fire charring on condition of ponderosa pine trees in Oregon as measured by longitudinal compression strength. Western Journal of Applied Forestry. 24(1): 33-35. doi:10.1093/wjaf/24.1.33

Karl, M.G.; Doescher, P.S. 1998. Ponderosa pine aboveground growth after cattle removal of terminal tissue. Journal of Range Management. 51(2): 147-151.

Karl, T.R.; Melillo, J.M.; Peterson, T.C. 2009. Global climate change impacts in the United States. New York: Cambridge University Press. 188 p. isbn:978-0-521-14407-0

Kashian, D.M.; Romme, W.H.; Tinker, D.B.; Turner, M.G.; Ryan, M.G. 2006. Carbon storage on landscapes with stand-replacing fires. BioScience. 56(7): 598-606. doi:10.1641/0006-3568(2006)56[598:CSOLWS]2.0.CO;2

Kauffman, J.B. 1990. Ecological relationships of vegetation and fire in Pacific Northwest forests. In: Walstad, J.D.; Radosevich, S.R.; Sandberg, D.V., eds. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press: 39-52. isbn:0-87071-359-0

Kauffman, J.B. 2004. Death rides the forest: perceptions of fire, land use, and ecological restoration of western forests. Conservation Biology. 18(4): 878-882. doi:10.1111/j.1523-1739.2004.545_1.x

Kaufmann, M.R. 1996. To live fast or not: growth, vigor and longevity of old-growth ponderosa pine and lodgepole pine trees. Tree Physiology. 16(1-2): 139-144. doi:10.1093/treephys/16.1-2.139

Kaufmann, M.R.; Stevens, R.E. 1984. Vigor of ponderosa pine trees surviving mountain pine beetle attack. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 5 p. https://archive.org/download/IND85026140/IND85026140.pdf

Kaufmann, M.R.; Graham, R.T.; Boyce, D.A., Jr.; Moir, W.H.; Perry, L.; Reynolds, R.T.; Bassett, R.L.; Mehlhop, P.; Edminster, C.B.; Block, W.M.; Corn, P.S. 1994. An ecological basis for ecosystem management. Gen. Tech. Rep. RM-246. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 22 p. http://www.treesearch.fs.fed.us/pubs/7612

Kaufmann, M.R.; Regan, C.M.; Brown, P.M. 2000. Heterogeneity in ponderosa pine/Douglas-fir forests: age and size structure in unlogged and logged landscapes of central Colorado. Canadian Journal of Forest Research. 30(5): 698-711. doi:10.1139/x99-255

Kaufmann, M.R.; Romme, W.R.; Ryan, K.; Fulé, P.Z. 2002. Restoration of ponderosa pine forests in the interior western United States after logging, grazing, and fire suppression. In: Proceedings of the IUFRO conference on restoration of boreal and temperate forests: documenting forest restoration knowledge and practices in boreal and temperate ecosystems. Denmark: Danish Center for Forest, Landscape and Planning: 60-61.

Kaufmann, M.R.; Huckaby, L.S.; Fornwalt, P.J.; Stoker, J.M.; Romme, W.H. 2003. Using tree recruitment patterns and fire history to guide restoration of an unlogged ponderosa pine/ Douglas-fir landscape in the southern Rocky Mountains after a century of fire suppression. Forestry. 76(2): 231-241. doi:10.1093/forestry/76.2.231

Kaufmann, M.R.; Binkley, D.; Fulé, P.Z.; Johnson, M.; Stephens, S.L.; Swetnam, T.W. 2007. Defining old growth for fire-adapted forests of the western United States. Ecology and Society. 12(2): article 15 (18 p). http://www.ecologyandsociety.org/vol12/iss2/art15/

Kay, C.E. 1994. Aboriginal overkill: the role of native Americans in structuring western ecosystems. Human Nature. 5(4): 359-398. doi:10.1007/BF02734166

Kay, C.E.; Simmons, R.T., eds. 2002. Wilderness and political ecology: aboriginal influences and the original state of nature. Salt Lake City, UT: University of Utah Press. 342 p. isbn:0-87480-719-0

Kaye, J.P.; Hart, S.C. 1998. Ecological restoration alters nitrogen transformations in a ponderosa pine-bunchgrass ecosystem. Ecological Applications. 8(4): 1052-1060. doi:10.1890/1051-0761(1998)008[1052:ERANTI]2.0.CO;2

Kaye, J.P.; Hart, S.C.; Fulé, P.Z.; Covington, W.W.; Moore, M.M.; Kaye, M.W. 2005. Initial carbon, nitrogen, and phosphorus fluxes following ponderosa pine restoration treatments. Ecological Applications. 15(5): 1581-1593. doi:10.1890/04-0868

Keane, R.E.; Arno, S.F.; Brown, J.K. 1990. Simulating cumulative fire effects in ponderosa pine/Douglas-fir forests. Ecology. 71(1): 189-203. doi:10.2307/1940259

Keane, R.E.; Morgan, P., Running, S.W. 1996. FIRE-BGC – A mechanistic ecological process model for simulating fire succession on coniferous forest landscapes of the northern Rocky Mountains. Res. Pap. INT-RP-484. Ogden, UT: USDA Forest Service, Intermountain Research Station. 122 p. https://archive.org/download/firebgcamechanis484kean/firebgcamechanis484kean.pdf

Keane, R.E.; Ryan, K.C.; Veblen, T.T.; Allen, C.D.; Logan, J.; Hawkes, B. 2002. Cascading effects of fire exclusion in Rocky Mountain ecosystems: a literature review. Gen. Tech. Rep. RMRS-GTR-91. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 24 p. https://www.fs.usda.gov/treesearch/pubs/5132

Keane, R.E.; Arno, S.; Dickinson, L.J. 2006. The complexity of managing fire-dependent ecosystems in wilderness: relict ponderosa pine in the Bob Marshall Wilderness. Ecological Restoration. 24(2): 71-78. doi:10.3368/er.24.2.71

Keeley, J.E.; McGinnis, T.W. 2007. Impact of prescribed fire and other factors on cheatgrass persistence in a Sierra Nevada ponderosa pine forest. International Journal of Wildland Fire. 16(1): 96-106. doi:10.1071/WF06052

Keeley, J.E.; Aplet, G.H.; Christensen, N.L.; Conard, S.G.; Johnson, E.A.; Omi, P.N.; Peterson, D.L.; Swetnam, T.W. 2009. Ecological foundations for fire management in North American forest and shrubland ecosystems. Gen. Tech. Rep. PNW-GTR-779. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 92 p. http://www.treesearch.fs.fed.us/pubs/32483

Keeley, W.H.; Germaine, S.S.; Stanley, T.R.; Spaulding, S.E.; Wanner, C.E. 2013. Response of brown-headed cowbirds and three host species to thinning treatments in low-elevation ponderosa pine forests along the northern Colorado Front Range. Forest Ecology and Management. 306: 226-233. doi:10.1016/j.foreco.2013.06.037

Keeling, E.G.; Sala, A. 2012. Changing growth response to wildfire in old-growth ponderosa pine trees in montane forests of north central Idaho. Global Change Biology. 18(3): 1117-1126. doi:10.1111/j.1365-2486.2011.02574.x

Keeling, E.G.; Sala, A.; DeLuca, T.H. 2006. Effects of fire exclusion on forest structure and composition in unlogged ponderosa pine/Douglas-fir forests. Forest Ecology and Management. 237(1-3): 418-428. doi:10.1016/j.foreco.2006.09.064

Keeling, E.G.; Sala, A.; DeLuca, T.H. 2011. Lack of fire has limited physiological impact on old-growth ponderosa pine in dry montane forests of north-central Idaho. Ecological Applications. 21(8): 3227-3237. doi:10.1890/10-1221.1

Keen, F.P. 1936. Relative susceptibility of ponderosa pines to bark-beetle attack. Journal of Forestry. 34(10): 919-927. doi:10.1093/jof/34.10.919

Keen, F.P. 1937. Climatic cycles in eastern Oregon as indicated by tree rings. Monthly Weather Review. 65(5): 175-188. doi:10.1175/1520-0493(1937)65<175:CCIEOA>2.0.CO;2

Keen, F.P. 1940. Longevity of ponderosa pine. Journal of Forestry. 38(7): 597-598. doi:10.1093/jof/38.7.586

Keen, F.P. 1950. The influence of insects on ponderosa pine silviculture. Journal of Forestry. 48(3): 186-188. doi:10.1093/jof/48.3.186

Keen, F.P. 1955. The rate of natural falling of beetle-killed ponderosa pine snags. Journal of Forestry. 53(10): 720-723. doi:10.1093/jof/53.10.720

Kegley, S.J.; Livingston, R.L.; Gibson, K.E. 1997. Pine engraver, *Ips pini* (Say), in the western United States. Forest Insect & Disease Leaflet 122. [Place of publication unknown]: USDA Forest Service. 8 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043668.pdf

Keith, J.O. 1965. The Abert squirrel and its dependence on ponderosa pine. Ecology. 46(1/2): 150-163. doi:10.2307/1935266

Keith, R.P.; Veblen, T.T.; Schoennagel, T.L.; Sherriff, R.L. 2010. Understory vegetation indicates historic fire regimes in ponderosa pine-dominated ecosystems in the Colorado Front Range. Journal of Vegetation Science. 21(3): 488-499. doi:10.1111/j.1654-1103.2009.01156.x

Kelly, L.T.; Brotons, L. 2017. Using fire to promote biodiversity. Science. 355(6331): 1264-1265. doi:10.1126/science.aam7672

Kelly, A.; Powell, D.C.; Riggs, R.A. 2005. Predicting potential natural vegetation in an interior northwest landscape using classification tree modeling and a GIS. Western Journal of Applied Forestry. 20(2): 117-127. doi:10.1093/wjaf/20.2.117

Kelsey, R.G. 2001. Chemical indicators of stress in trees: their ecological significance and implication for forestry in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 70-76. http://hdl.handle.net/2376/983

Kelsey, R.G.; Harrington, M.G. 1979. A search for phytotoxins influencing germination and early growth of ponderosa pine. Res. Pap. INT-216. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 28 p. https://archive.org/download/searchforphytoto216kels/searchforphytoto216kels.pdf

Kelsey, R.G.; Joseph, G. 2003. Ethanol in ponderosa pine as an indicator of physiological injury from fire and its relationship to secondary beetles. Canadian Journal of Forest Research. 33(5): 870-884. doi:10.1139/x03-007

Kelsey, R.G.; Westlind, D.J. 2017a. Ethanol and primary attraction of red turpentine beetle in fire stressed ponderosa pine. Forest Ecology and Management. 396: 44-54.

doi:10.1016/j.foreco.2017.04.009

Kelsey, R.G.; Westlind, D.J. 2017b. Physiological stress and ethanol accumulation in tree stems and woody tissues at sublethal temperatures from fire. BioScience. 67(5): 443-451. doi:10.1093/biosci/bix037

Kelsey, R.G.; Joseph, G.; Thies, W.G. 1998. Sapwood and crown symptoms in ponderosa pine infected with black-stain and annosum root disease. Forest Ecology and Management. 111(2-3): 181-191. doi:10.1016/S0378-1127(98)00332-6

Kelsey, R.G.; Thies, W.G.; Schmitt, C.L. 2006. Using chemical markers to detect root disease in stressed ponderosa pine stands with a low incidence of disease in eastern Oregon. Forest Ecology and Management. 232(1-3): 205-215. doi:10.1016/j.foreco.2006.05.073

Kemp, K.B.; Higuera, P.E.; Morgan, P. 2016. Fire legacies impact conifer regeneration across environmental gradients in the U.S. northern Rockies. Landscape Ecology. 31(3): 619-636. doi:10.1007/s10980-015-0268-3

Kemp, K.B.; Higuera, P.E.; Morgan, P.; Abatzoglou, J.T. 2019. Climate will increasingly determine post-fire tree regeneration success in low-elevation forests, Northern Rockies, USA. Ecosphere. 10(1): e02568 (17 p). doi:10.1002/ecs2.2568

Kennedy, P.L.; Fontaine, J.B. 2009. Synthesis of knowledge on the effects of fire and fire surrogates on wildlife in U.S. dry forests. Special Report 1096. Corvallis, OR: Oregon State University, Agricultural Experimental Station. 132 p. https://www.frames.gov/documents/ffs/ffs087_kennedy_wildlife.pdf

Kennedy, M.C.; Johnson, M.C.; Fallon, K.; Mayer, D. 2019. How big is enough? Vegetation structure impacts effective fuel treatment width and forest resiliency. Ecosphere. 10(2): e02573 (11 p). doi:10.1002/ecs2.2573

Kent, W.H.B. 1904. The proposed Wenaha Forest Reserve, Washington and Oregon: examination and report. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 22 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015539.pdf

Kent, M.; Coker, P. 2002. Vegetation description and analysis: a practical approach. Chichester, UK: John Wiley & Sons. 363 p. isbn:0-471-94810-1

Kenworthy, T. 1992. 'Unraveling' of ecosystem looms in Oregon forests: scientists say recovery could take century. Washington, DC: Washington Post, Friday, May 15th, page A01.

Kerhoulas, L.P.; Kolb, T.E.; Koch, G.W. 2013. Tree size, stand density, and the source of water used across seasons by ponderosa pine in northern Arizona. Forest Ecology and Management. 289: 425-433. doi:10.1016/j.foreco.2012.10.036

Kernan, J.T.; Hessl, A.E. 2010. Spatially heterogeneous estimates of fire frequency in ponderosa pine forests of Washington, USA. Fire Ecology. 6(3): 117-135. doi:10.4996/fireecology.0603117

Kerns, B.K.; Day, M.A. 2017. The importance of disturbance by fire and other abiotic and biotic factors in driving cheatgrass invasion varies based on invasion stage. Biological Invasions. 19(6): 1853-1862. doi:10.1007/s10530-017-1395-3

Kerns, B.K.; Day, M.A. 2018. Prescribed fire regimes subtly alter ponderosa pine forest plant community structure. Ecosphere. 9(12): e02529 (20 p). doi:10.1002/ecs2.2529

Kerns, B.K.; Westlind, D.J. 2013. Effect of season and interval of prescribed burn on ponderosa pine butterfly defoliation patterns. Canadian Journal of Forest Research. 43(10): 979-983.

doi:10.1139/cjfr-2013-0153

Kerns, B.K.; Moore, M.M.; Timpson, M.E.; Hart, S.C. 2003. Soil properties associated with vegetation patches in a *Pinus ponderosa*—bunchgrass mosaic. Western North American Naturalist. 63(4): 452-462. https://scholarsarchive.byu.edu/wnan/vol63/iss4/5

Kerns, B.K.; Thies, W.G.; Niwa, C.G. 2006. Season and severity of prescribed burn in ponderosa pine forests: implications for understory native and exotic plants. Ecoscience. 13(1): 44-55. doi:10.2980/1195-6860(2006)13[44:SASOPB]2.0.CO;2

Kerns, B.K.; Buonopane, M.; Thies, W.G.; Niwa, C. 2011. Reintroducing fire into a ponderosa pine forest with and without cattle grazing: understory vegetation response. Ecosphere. 2(5): art59 (23 p). doi:10.1890/ES10-00183.1

Kerns, B.K.; Powell, D.C.; Mellmann-Brown, S.; Carnwath, G.; Kim, J.B. 2017. Chapter 6: Effects of climatic variability and change on upland vegetation in the Blue Mountains. In: Halofsky, J.E.; Peterson, D.L., eds. Climate change vulnerability and adaptation in the Blue Mountains region. Gen. Tech. Rep. PNW-GTR-939. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 149-250. https://www.fs.usda.gov/treesearch/pubs/54509

Kerns, B.K.; Powell, D.C.; Mellmann-Brown, S.; Carnwath, G.; Kim, J.B. 2018. Effects of projected climate change on vegetation in the Blue Mountains ecoregion, USA. Climate Services. 10: 33-43. doi:10.1016/j.cliser.2017.07.002

Kerr, A. 2007. Thinning certain Oregon forests to restore ecological function. Occasional Paper #3. Ashland, OR: The Larch Company. 31 p. http://www.andykerr.net/storage/other-matters-uploads/LOP%203%20Small%201.0.pdf

Keyes, C.R. 1996. Stand structures and silvicultural strategies to prevent crown fires in northern Rocky Mountain forests. M.S. thesis. Missoula, MT: University of Montana. 116 p.

Keyes, C.R. 2000. Natural regeneration of ponderosa pine: pest management strategies for seed predators. Forestry Chronicle. 76(4): 623-626. doi:10.5558/tfc76623-4

Keyes, M.R.; Grier, C.C. 1981. Above- and below-ground net production in 40-year-old Douglas-fir stands on low and high productivity sites. Canadian Journal of Forest Research. 11(3): 599-605. doi:10.1139/x81-082

Keyes, C.R.; Acker, S.A.; Greene, S.E. 2001. Overstory and shrub influences on seedling recruitment patterns in an old-growth ponderosa pine stand. Northwest Science. 75(3): 204-210. http://hdl.handle.net/2376/937

Keyes, C.R.; Maguire, D.A.; Tappeiner, J.C. 2007. Observed dynamics of ponderosa pine (*Pinus ponderosa* var. *ponderosa* Dougl. ex Laws.) seedling recruitment in the Cascade Range, USA. New Forests. 34(1): 95-105. doi:10.1007/s11056-007-9041-z

Keyser, C.E.; Milner, K.S. 2003. Ponderosa pine and lodgepole pine growth response to one-time application of herbicide during seedling establishment in western Montana. Western Journal of Applied Forestry. 18(3): 149-154. doi:10.1093/wjaf/18.3.149

Keyser, A.R.; Westerling, A.L. 2019. Predicting increasing high severity area burned for three forested regions in the western United States using extreme value theory. Forest Ecology and Management. 432: 694-706. doi:10.1016/j.foreco.2018.09.027

Keyser, T.L.; Smith, F.W.; Lentile, L.B.; Shepperd, W.D. 2006. Modeling postfire mortality of ponderosa pine following a mixed-severity wildfire in the Black Hills: the role of tree morphology and direct fire effects. Forest Science. 52(5): 530-539. doi:10.1093/forestscience/52.5.530

Keyser, T.L.; Lentile, L.B.; Smith, F.W.; Shepperd, W.D. 2008. Changes in forest structure after a large, mixed-severity wildfire in ponderosa pine forests of the Black Hills, South Dakota, USA. Forest Science. 54(3): 328-338. doi:10.1093/forestscience/54.3.328

Keyser, T.L.; Smith, F.W.; Shepperd, W.D. 2009. Short-term impact of post-fire salvage logging on regeneration, hazardous fuel accumulation, and understorey development in ponderosa pine forests of the Black Hills, SD, USA. International Journal of Wildland Fire. 18(4): 451-458. doi:10.1071/WF08004

Keyser, T.L.; Smith, F.W.; Shepperd, W.D. 2010. Growth response of Pinus ponderosa following a mixed-severity wildfire in the Black Hills, South Dakota. Western Journal of Applied Forestry. 25(2): 49-54. doi:10.1093/wjaf/25.2.49

Khanduri, V.P.; Sharma, C.M.; Singh, S.P. 2008. The effects of climate change on plant phenology. Environmentalist. 28(2): 143-147. doi:10.1007/s10669-007-9153-1

Kie, J.G.; Lehmkuhl, J.F. 2001. Herbivory by wild and domestic ungulates in the intermountain west. Northwest Science. 75(Special Issue): 55-61. http://hdl.handle.net/2376/981

Kilgore, B.M.; Curtis, G.A. 1987. Guide to understory burning in ponderosa pine-larch-fir forests in the intermountain west. Gen. Tech. Rep. INT-233. Ogden, UT: USDA Forest Service, Intermountain Research Station. 39 p. https://www.fs.usda.gov/treesearch/pubs/32954

Kimmerer, R.W. 2000. Native knowledge for native ecosystems. Journal of Forestry. 98(8): 4-9. doi:10.1093/jof/98.8.4

Kimmerer, R.W.; Lake, F.K. 2001. The role of indigenous burning in land management. Journal of Forestry. 99(11): 36-41. doi:10.1093/jof/99.11.36

Kimmins, J.P. 1997. Forest ecology; a foundation for sustainable management. 2nd edition. Upper Saddle River, NJ: Prentice Hall. 596 p. isbn:0-02-364071-5

Kingery, J.L.; Graham, R.T. 1991. The effect of cattle grazing on ponderosa pine regeneration. Forestry Chronicle. 67(3): 245-248. doi:10.5558/tfc67245-3

Kitzberger, T.; Aráoz, E.; Gowda, J.; Mermoz, M.; Morales, J. 2012. Decreases in fire spread probability with forest age promotes alternative community states, reduced resilience to climate variability and large fire regime shifts. Ecosystems. 15(1): 97-112. doi:10.1007/s10021-011-9494-y

Kitzhaber, J.A.; Forsgren, H.; Zielinski, E. 2001. An 11-point strategy for restoring eastern Oregon forests, watersheds and communities (dated April 13). Three-page enclosure with a memorandum to Forest Supervisors and District Managers (file code 2510; memo dated June 14, 2001).

Klemmedson, J.O. 1976. Effect of thinning and slash burning on nitrogen and carbon in ecosystems of young dense ponderosa pine. Forest Science. 22(1): 45-53. doi:10.1093/forestscience/22.1.45

Klemmedson, J.O. 1979. Ecological importance of actinomycete-nodulated plants in the western United States. Botanical Gazette. 140(Supplement): S91-S96. doi:10.2307/2474210

Klenner, W.; Arsenault, A. 2009. Ponderosa pine mortality during a severe bark beetle (Coleoptera: Curculionidae, Scolytinae) outbreak in southern British Columbia and implications for wildlife habitat management. Forest Ecology and Management. 258(Supplement): S5-S14. doi:10.1016/j.foreco.2009.08.035

Klenner, W.; Sullivan, T.P. 2009. Partial and clearcut harvesting of dry Douglas-fir forests: Implications for small mammal communities. Forest Ecology and Management. 257(3): 1078-

1086. doi:10.1016/j.foreco.2008.11.012

Klenner, W.; Walton, R. 2009. Landscape-level habitat supply modelling to develop and evaluate management practices that maintain diverse forest values in a dry forest ecosystem in southern British Columbia. Forest Ecology and Management. 258(Supplement): S146-S157. doi:10.1016/j.foreco.2009.07.047

Klenner, W.; Kurz, W.; Beukema, S. 2000. Habitat patterns in forested landscapes: management practices and the uncertainty associated with natural disturbances. Computers and Electronics in Agriculture. 27(1-3): 243-262. doi:10.1016/S0168-1699(00)00110-1

Klenner, W.; Walton, R.; Arsenault, A.; Kremsater, L. 2008. Dry forests in the southern interior of British Columbia: historic disturbances and implications for restoration and management. Forest Ecology and Management. 256(10): 1711-1722. doi:10.1016/j.foreco.2008.02.047

Kloor, K. 2000. Returning America's forests to their 'natural' roots. Science. 287(5453): 573-575. doi:10.1126/science.287.5453.573

Klutsch, J.G.; Beam, R.D.; Jacobi, W.R.; Negrón, J.F. 2014. Bark beetles and dwarf mistletoe interact to alter downed woody material, canopy structure, and stand characteristics in northern Colorado ponderosa pine. Forest Ecology and Management. 315: 63-71. doi:10.1016/j.foreco.2013.12.024

Knapp, E.E.; Keeley, J.E. 2006. Heterogeneity in fire severity within early season and late season prescribed burns in a mixed-conifer forest. International Journal of Wildland Fire. 15(1): 37-45. doi:10.1071/WF04068

Knapp, P.A.; Soulé, P.T. 1998. Recent *Juniperus occidentalis* (western juniper) expansion on a protected site in central Oregon. Global Change Biology. 4(3): 347-357. doi:10.1046/j.1365-2486.1998.00160.x

Knapp, P.A.; Soulé, P.T. 2011. Increasing water-use efficiency and age-specific growth responses of old-growth ponderosa pine trees in the northern Rockies. Global Change Biology. 17(1): 631-641. doi:10.1111/j.1365-2486.2010.02209.x

Knapp, P.; Soulé, P. 2017. Spatio-temporal linkages between declining arctic sea-ice extent and increasing wildfire activity in the western United States. Forests. 8(9): 313. (13 p). doi:10.3390/f8090313

Knapp, E.E.; Schwilk, D.W.; Kane, J.M.; Keeley, J.E. 2007. Role of burning season on initial understory vegetation response to prescribed fire in a mixed conifer forest. Canadian Journal of Forest Research. 37(1): 11-22. doi:10.1139/x06-200

Knapp, E.E.; Estes, B.L.; Skinner, C.N. 2009. Ecological effects of prescribed fire season: A literature review and synthesis for managers. Gen. Tech. Rep. PSW-GTR-224. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 80 p. http://www.treesearch.fs.fed.us/pubs/33628

Knapp, E.E.; Skinner, C.N.; North, M.P.; Estes, B.L. 2013. Long-term overstory and understory change following logging and fire exclusion in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management. 310: 903-914. doi:10.1016/j.foreco.2013.09.041

Knapp, E.E.; Lydersen, J.M.; North, M.P.; Collins, B.M. 2017. Efficacy of variable density thinning and prescribed fire for restoring forest heterogeneity to mixed-conifer forest in the central Sierra Nevada, CA. Forest Ecology and Management. 406: 228-241. doi:10.1016/j.foreco.2017.08.028

Knapp, E.E.; Bernal, A.A.; Kane, J.M.; Fettig, C.J.; North, M.P. 2021. Variable thinning and prescribed fire influence tree mortality and growth during and after a severe drought. Forest

Ecology and Management. 479: 118595. doi:10.1016/j.foreco.2020.118595

Knudson, R. 1980. Ancient peoples of the Columbia plateau. Journal of Forestry. 78(8): 477-479. doi:10.1093/jof/78.8.477

Knutson, D.M. 1975. Dwarf mistletoe-infected ponderosa pines survive top-pruning. Journal of Forestry. 73(12): 774-775. doi:10.1093/jof/73.12.774

Knutson, K.C.; Pyke, D.A. 2008. Western juniper and ponderosa pine ecotonal climate–growth relationships across landscape gradients in southern Oregon. Canadian Journal of Forest Research. 38(12): 3021-3032. doi:10.1139/X08-142

Knutson, D.M.; Toevs, W.J. 1972. Dwarf mistletoe reduces root growth of ponderosa pine seedlings. Forest Science. 18(4): 323-324. doi:10.1093/forestscience/18.4.323

Kobziar, L.; Moghaddas, J.; Stephens, S.L. 2006. Tree mortality patterns following prescribed fires in a mixed conifer forest. Canadian Journal of Forest Research. 36(12): 3222-3238. doi:10.1139/x06-183

Kobziar, L.N.; McBride, J.R.; Stephens, S.L. 2009. The efficacy of fire and fuels reduction treatments in a Sierra Nevada pine plantation. International Journal of Wildland Fire. 18(7): 791-801. doi:10.1071/WF06097

Koch, E. 1923. The inferior species in the white pine type in Montana and Idaho. Journal of Forestry. 21(6): 588-599. doi:10.1093/jof/21.6.588

Kolb, P.F.; Robberecht, R. 1996a. High temperature and drought stress effects on survival of *Pinus ponderosa* seedlings. Tree Physiology. 16(8): 665-672. doi:10.1093/treephys/16.8.665

Kolb, P.F.; Robberecht, R. 1996b. *Pinus ponderosa* seedling establishment and the influence of competition with the bunchgrass *Agropyron spicatum*. International Journal of Plant Sciences. 157(4): 509-515. doi:10.2307/2475256

Kolb, P.F.; Adams, D.L.; McDonald, G.I. 1998a. Impacts of fire exclusion on forest dynamics and processes in central Idaho. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL: Tall Timbers Research Station: 210-218. https://talltimbers.org/wp-content/uploads/2018/09/210-Kolbetal1998_op.pdf

Kolb, T.E.; Holmberg, K.M.; Wagner, M.R.; Stone, J.E. 1998b. Regulation of ponderosa pine foliar physiology and insect resistance mechanisms by basal area treatments. Tree Physiology. 18(6): 375-381. doi:10.1093/treephys/18.6.375

Kolb, T.E.; Agee, J.K.; Fule, P.Z.; McDowell, N.G.; Pearson, K.; Sala, A.; Waring, R.H. 2007. Perpetuating old ponderosa pine. Forest Ecology and Management. 249(3): 141-157. doi:10.1016/j.foreco.2007.06.002

Kolden, C.A.; Abatzoglou, J.T.; Lutz, J.A.; Cansler, C.A.; Kane, J.T.; Wagtendonk, J.W.V.; Key, C.H. 2015. Climate contributors to forest mosaics: Ecological persistence following wildfire. Northwest Science. 89(3): 219-238. doi:10.3955/046.089.0305

Kondolf, G.M.; Boulton, A.J.; O'Daniel, S.; Poole, G.C.; Rahel, F.J.; Stanley, E.H.; Wohl, E.; Bång, A.; Carlstrom, J.; Cristoni, C.; Huber, H.; Koljonen, S.; Louhi, P.; Nakamura, K. 2006. Process-based ecological river restoration: Visualizing three-dimensional connectivity and dynamic vectors to recover lost linkages. Ecology and Society. 11(2): 5 (17 p). doi:10.5751/ES-01747-110205

Konoshima, M.; Albers, H.J.; Montgomery, C.A.; Arthur, J.L. 2010. Optimal spatial patterns of fuel management and timber harvest with fire risk. Canadian Journal of Forest Research.

40(1): 95-108. doi:10.1139/X09-176

Koonce, A.L.; Roth, L.F. 1980. The effects of prescribed burning on dwarf mistletoe in ponderosa pine. In: Martin, R.E.; Edmonds, R.L.; Faulkner, D.A.; Harrington, J.B.; Fuquay, D.M.; Stocks, B.J.; Barr, S., eds. Proceedings; sixth conference on fire and forest meteorology. Washington, DC: Society of American Foresters: 197-203.

Korb, J.E.; Covington, W.W.; Fulé, P.Z. 2003. Sampling techniques influence understory plant trajectories after restoration: an example from ponderosa pine restoration. Restoration Ecology. 11(4): 504-515. doi:10.1046/j.1526-100X.2003.rec0170.x

Korb, J.E.; Springer, J.D.; Powers, S.R.; Moore, M.M. 2005. Soil seed banks in *Pinus ponderosa* forests in Arizona: Clues to site history and restoration potential. Applied Vegetation Science. 8(1): 103-112. doi:10.1111/j.1654-109X.2005.tb00634.x

Korb, J.E.; Daniels, M.L.; Laughlin, D.C.; Fulé, P.Z. 2007. Understory communities of warm-dry, mixed-conifer forests in southwestern Colorado. Southwestern Naturalist. 52(4): 493-503. doi:10.1894/0038-4909(2007)52[493:UCOWMF]2.0.CO;2

Korb, J.E.; Fulé, P.Z.; Stoddard, M.T. 2012. Forest restoration in a surface fire-dependent ecosystem: an example from a mixed conifer forest, southwestern Colorado, USA. Forest Ecology and Management. 269: 10-18. doi:10.1016/j.foreco.2012.01.002

Korb, J.E.; Fulé, P.Z.; Wu, R. 2013. Variability of warm/dry mixed conifer forests in southwestern Colorado, USA: Implications for ecological restoration. Forest Ecology and Management. 304: 182-191. doi:10.1016/j.foreco.2013.04.028

Korb, J.E.; Fornwalt, P.J.; Stevens-Rumann, C.S. 2019. What drives ponderosa pine regeneration following wildfire in the western United States? Forest Ecology and Management. 454: 117663 (16 p). doi:10.1016/j.foreco.2019.117663

Korstian, C.F. 1924a. A silvical comparison of the Pacific coast and Rocky Mountain forms of western yellow pine. American Journal of Botany. 11(5): 318-324. doi:10.1002/j.1537-2197.1924.tb05779.x

Korstian, C.F. 1924b. Growth on cut-over and virgin western yellow pine lands in central Idaho. Journal of Agricultural Research. 28(11): 1139-1148. https://naldc.nal.usda.gov/download/IND43966827/PDF

Korstian, C.F.; Baker, F.S. 1922. Is Douglas fir replacing western yellow pine in central Idaho? Journal of Forestry. 20(7): 755-764. doi:10.1093/jof/20.7.755

Kotliar, N.B.; Hejl, S.J.; Hutto, R.L.; Saab, V.A.; Melcher, C.P.; McFadzen, M.E. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology. 25: 49-64. Kotliar et al 2002

Kovacic, D.A.; Swift, D.M.; Ellis, J.E.; Hakonson, T.E. 1986. Immediate effects of prescribed burning on mineral soil nitrogen in ponderosa pine of New Mexico. Soil Science. 141(1): 71-76.

Kozma, J.M. 2011. Composition of forest stands used by white-headed woodpeckers for nesting in Washington. Western North American Naturalist. 71(1): 1-9. doi:10.3398/064.071.0101

Kozma, J.M. 2012. Nest-site characteristics of three woodpecker species in managed ponderosa pine forests of the eastern Cascade range. Northwestern Naturalist. 93(2): 111-119. doi:10.1898/nwn11-10.1

Kramer, H.J. 1938. A brief history of the pine industry of Union, Wallowa, Baker, and Grant counties of Oregon. M.A. thesis. Eugene, OR: University of Oregon. 76 p.

Krannitz, P.G.; Duralia, T.E. 2004. Cone and seed production in *Pinus ponderosa*: a review. Western North American Naturalist. 64(2): 208-218. https://scholarsarchive.byu.edu/wnan/vol64/iss2/8

Krawchuk, M.A.; Meigs, G.W.; Cartwright, J.M.; Coop, J.D.; Davis, R.; Holz, A.; Kolden, C.; Meddens, A.J. 2020. Disturbance refugia within mosaics of forest fire, drought, and insect outbreaks. Frontiers in Ecology and the Environment. 18(5): 235-244. doi:10.1002/fee.2190

Kreye, J.K.; Brewer, N.W.; Morgan, P.; Varner, J.M.; Smith, A.M.S.; Hoffman, C.M.; Ottmar, R.D. 2014. Fire behavior in masticated fuels: A review. Forest Ecology and Management. 314: 193-207. doi:10.1016/j.foreco.2013.11.035

Krieger, D.J. 2001. Economic value of forest ecosystem services: a review. Washington, DC: The Wilderness Society. 31 p. http://www.cfr.washington.edu/classes.esrm.465/2007/readings/ws_valuation.pdf

Kruse, W.H. 1972. Effects of wildfire on elk and deer use of a ponderosa pine forest. Res. Note RM-226. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. EffectsofwildfireonelkanddeeruseofaPonderosaPineforest

Lake, F.K.; Wright, V.; Morgan, P.; McFadzen, M.; McWethy, D.; Stevens-Rumann, C. 2017. Returning fire to the land: Celebrating traditional knowledge and fire. Journal of Forestry. 115(5): 343-353. doi:10.5849/jof.2016-043R2

Landhäusser, S.M.; Pinno, B.D.; Mock, K.E. 2019. Tamm Review: Seedling-based ecology, management, and restoration in aspen (*Populus tremuloides*). Forest Ecology and Management. 432: 231-245. doi:10.1016/j.foreco.2018.09.024

Landres, P.B.; Morgan, P.; Swanson, F.J. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications. 9(4): 1179-1188. doi:10.1890/1051-0761(1999)009[1179:OOTUON]2.0.CO;2

Landsberg, J.D.; Cochran, P.H.; Finck, M.M.; Martin, R.E. 1984. Foliar nitrogen content and tree growth after prescribed fire in ponderosa pine. Res. Note PNW-412. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 15 p. https://www.fs.usda.gov/treesearch/pubs/26780

Langenheim, J.H. 1990. Plant resins. American Scientist. 78 (1): 16-24. http://www.jstor.org/stable/29773859

Langille, H.D. 1903. The proposed Heppner Forest Reserve, Oregon. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 32 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015593.pdf

Langille, H.D. 1906. Report on the proposed Blue Mountains Forest Reserve. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 40 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015626.pdf

Langston, N. 1995. Forest dreams, forest nightmares: the paradox of old growth in the inland west. Seattle, WA: University of Washington Press. 368 p. isbn:0-295-97456-7

Lanini, W.T.; Radosevich, S.R. 1986. Response of three conifer species to site preparation and shrub control. Forest Science. 32(1): 61-77. doi:10.1093/forestscience/32.1.61

Larson, A.J.; Churchill, D. 2012. Tree spatial patterns in fire-frequent forests of western North America, including mechanisms of pattern formation and implications for designing fuel reduction and restoration treatments. Forest Ecology and Management. 267: 74-92. doi:10.1016/j.foreco.2011.11.038

Larson, D.; Mirth, R. 1998. Potential for using small-diameter ponderosa pine: a wood fiber projection. Forest Products Journal. 48(6): 37-42.

Larson, M.M.; Schubert, G.H. 1969. Root competition between ponderosa pine seedlings and grass. Res. Pap. RM-54. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p. https://archive.org/download/CAT92273102/CAT92273102.pdf

Larson, F.; Whitman, W. 1942. A comparison of used and unused grassland mesas in the badlands of South Dakota. Ecology. 23(4): 438-445. doi:10.2307/1930130

Larson, F.R.; Ffolliott, P.F.; Thill, R.E.; Clary, W.P. 1977. Animal use of ponderosa pine forest openings. Journal of Wildlife Management. 41(4): 782-784. doi:10.2307/3800008

Larson, A.J.; Stover, K.C.; Keyes, C.R. 2012. Effects of restoration thinning on spatial heterogeneity in mixed-conifer forest. Canadian Journal of Forest Research. 42(8): 1505-1517. doi:10.1139/x2012-100

Larson, A.J.; Belote, R.T.; Cansler, C.A.; Parks, S.A.; Dietz, M.S. 2013. Latent resilience in ponderosa pine forest: effects of resumed frequent fire. Ecological Applications. 23(6): 1243-1249. doi:10.1890/13-0066.1

Larsson, S.; Oren, R.; Waring, R.H.; Barrett, J.W. 1983. Attacks of mountain pine beetle as related to tree vigor of ponderosa pine. Forest Science. 29(2): 395-402. doi:10.1093/forestscience/29.2.395

Latif, Q.S.; Sanderlin, J.S.; Saab, V.A.; Block, W.M.; Dudley, J.G. 2016. Avian relationships with wildfire at two dry forest locations with different historical fire regimes. Ecosphere. 7(5): e01346 (22 p). doi:10.1002/ecs2.1346

Latif, Q.S.; Truex, R.L.; Sparks, R.A.; Pavlacky, D.C., Jr. 2020. Dry conifer forest restoration benefits Colorado Front Range avian communities. Ecological Applications. 30(6): e02142 (20 p). doi:10.1002/eap.2142

Laudenslayer, W.F., Jr.; Darr, H.H.; Smith, S. 1989. Historical effects of forest management practices on eastside pine communities in northeastern California. In: Tecle, A.; Covington, W.W.; Hamre, R.H., tech. coords. Multiresource management of ponderosa pine forests. Gen. Tech. Rep. RM-185. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 26-34. https://archive.org/download/CAT10400419/CAT10400419.pdf

Laughlin, D.C.; Abella, S.R. 2007. Abiotic and biotic factors explain independent gradients of plant community composition in ponderosa pine forests. Ecological Modelling. 205(1-2): 231-240. doi:10.1016/j.ecolmodel.2007.02.018

Laughlin, D.C.; Bakker, J.D.; Stoddard, M.T.; Daniels, M.L.; Springer, J.D.; Gildar, C.N.; Green, A.M.; Covington, W.W. 2004. Toward reference conditions: wildfire effects on flora in an old-growth ponderosa pine forest. Forest Ecology and Management. 199(1): 137-152. doi:10.1016/j.foreco.2004.05.034

Laughlin, D.C.; Moore, M.M.; Bakker, J.D.; Casey, C.A.; Springer, J.D.; Fulé, P.Z.; Covington, W.W. 2006. Assessing targets for the restoration of herbaceous vegetation in ponderosa pine forests. Restoration Ecology. 14(4): 548-560. doi:10.1111/j.1526-100X.2006.00166.x

Laughlin, D.C.; Abella, S.R.; Covington, W.W.; Grace, J.B. 2007. Species richness and soil properties in *Pinus ponderosa* forests: a structural equation modeling analysis. Journal of Vegetation Science. 18(2): 229-240. doi:10.1111/j.1654-1103.2007.tb02534.x

Laven, R.D.; Omi, P.N.; Wyant, J.G.; Pinkerton, A.S. 1980. Interpretation of fire scar data from a ponderosa pine ecosystem in the central Rocky Mountains, Colorado. In: Stokes, M.A.; Dieterich, J.H., tech. coords. Proceedings of the fire history workshop. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 46-49. https://www.fs.usda.gov/treesearch/pubs/41408

Laverty, L.; Williams, J. 2000. Protecting people and sustaining resources in fire-adapted ecosystems: a cohesive strategy. Washington, DC: USDA Forest Service. 85 p. http://purl.access.gpo.gov/GPO/LPS36187

Law, D.J.; Kolb, P.F. 2007. The effects of forest residual debris disposal on perennial grass emergence, growth, and survival in a ponderosa pine ecotone. Rangeland Ecology and Management. 60(6): 632-643. doi:10.2111/06-034R4.1

Law, B.E.; Ryan, M.G.; Anthoni, P.M. 1999. Seasonal and annual respiration of a ponderosa pine ecosystem. Global Change Biology. 5(2): 169-182. doi:10.1046/j.1365-2486.1999.00214.x

Law, B.E.; Goldstein, A.H.; Anthoni, P.M.; Unsworth, M.H.; Panek, J.A.; Bauer, M.R.; Fracheboud, J.M.; Hultman, N. 2001. Carbon dioxide and water vapor exchange by young and old ponderosa pine ecosystems during a dry summer. Tree Physiology. 21(5): 299-308. doi:10.1093/treephys/21.5.299

Law, B.E.; Thornton, P.E.; Irvine, J.; Anthoni, P.M.; Tuyl, S.V. 2001. Carbon storage and fluxes in ponderosa pine forests at different developmental stages. Global Change Biology. 7(7): 755-777. doi:10.1046/j.1354-1013.2001.00439.x

Law, B.E.; Sun, O.J.; Campbell, J.; Tuyl, S.V.; Thornton, P.E. 2003. Changes in carbon storage and fluxes in a chronosequence of ponderosa pine. Global Change Biology. 9(4): 510-524. doi:10.1046/j.1365-2486.2003.00624.x

LeDoux, C.B.; Martin, D.K. 2013. Proposed BMPs for invasive plant mitigation during timber harvesting operations. Gen. Tech. Rep. NRS-118. Newtown Square, PA: USDA Forest Service, Northern Research Station. 12 p. https://www.fs.usda.gov/treesearch/pubs/44182

Leege, T.A.; Hickey, W.O. 1971. Sprouting of northern Idaho shrubs after prescribed burning. Journal of Wildlife Management. 35(3): 508-515. doi:10.2307/3799705

Lehmann, J.; Joseph, S., eds. 2009. Biochar for environmental management: science and technology. Sterling, VA: Earthscan. 416 p. isbn:978-1-84407-658-1

Lehmkuhl, J.F.; Hessburg, P.F.; Everett, R.L.; Huff, M.H.; Ottmar, R.D. 1994. Historical and current forest landscapes of eastern Oregon and Washington. Part 1: Vegetation pattern and insect and disease hazards. Gen. Tech. Rep. PNW-GTR-328. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 88 p. http://www.treesearch.fs.fed.us/pubs/6407

Lehmkuhl, J.F.; Kennedy, M.; Ford, E.D.; Singleton, P.H.; Gaines, W.L.; Lind, R.L. 2007. Seeing the forest for the fuel: integrating ecological values and fuels management. Forest Ecology and Management. 246(1): 73-80. doi:10.1016/j.foreco.2007.03.071

Lehmkuhl, J.F.; Lyons, A.L.; Bracken, E.; Leingang, J.; Gaines, W.L.; Dodson, E.K.; Singleton, P.H. 2013. Forage composition, productivity, and utilization in the eastern Washington Cascade Range. Northwest Science. 87(4): 267-291. doi:10.3955/046.087.0404

Leirfallom, S.B.; Keane, R.E. 2011. Six-year post-fire mortality and health of relict ponderosa pines in the Bob Marshall Wilderness Area, Montana. Res. Note RMRS-RN-42. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 6 p. http://www.treesearch.fs.fed.us/pubs/37288

Lemmon, P.E.; Schumacher, F.X. 1962. Stocking density around ponderosa pine trees. Forest Science. 8(4): 397-402. doi:10.1093/forestscience/8.4.397

Lenihan, J.M.; Bachelet, D.; Neilson, R.P.; Drapek, R. 2008a. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climatic Change. 87(1): 215-230. doi:10.1007/s10584-007-9362-0

Lenihan, J.M.; Bachelet, D.; Neilson, R.P.; Drapek, R. 2008b. Simulated response of conterminous United States ecosystems to climate change at different levels of fire suppression, CO_2 emission rate, and growth response to CO_2. Global and Planetary Change. 64(1-2): 16-25. doi:10.1016/j.gloplacha.2008.01.006

Lentile, L.B.; Smith, F.W.; Shepperd, W.D. 2006. Influence of topography and forest structure on patterns of mixed severity fire in ponderosa pine forests of the South Dakota Black Hills, USA. International Journal of Wildland Fire. 15(4): 557-566. doi:10.1071/WF05096

Lerch, A.P.; Pfammatter, J.A.; Bentz, B.J.; Raffa, K.F. 2016. Mountain pine beetle dynamics and reproductive success in post-fire lodgepole and ponderosa pine forests in northeastern Utah. PLoS ONE. 11(10): e0164738 (22 p). doi:10.1371/journal.pone.0164738

Lesica, P. 1996. Using fire history models to estimate proportions of old growth forest in northwest Montana, USA. Biological Conservation. 77(1): 33-39. doi:10.1016/0006-3207(95)00130-1

Lesser, M.R.; Jackson, S.T. 2012. Making a stand: five centuries of population growth in colonizing populations of *Pinus ponderosa*. Ecology. 93(5): 1071-1081. doi:10.1890/0012-9658-93.5.1071

LeVan-Green, S.L.; Livingston, J. 2001. Exploring the uses for small-diameter trees. Forest Products Journal. 51(9): 10-21. docview/214633595/1403674667A761575FE/

LeVan-Green, S.L.; Livingston, J.M. 2003. Uses for small-diameter and low-value forest thinnings. Ecological Restoration. 21(1): 34-38. doi:10.3368/er.21.1.34

Lewis, P.; Kauffman, M.R.; Huckaby, L.S. 2005. Report on the health of Colorado's forests 2004; special issue: ponderosa pine forests. Denver, CO: Colorado Department of Natural Resources, Division of Forestry. 32 p. https://www.fs.usda.gov/treesearch/pubs/43614

Lexen, B. 1939. Space requirement of ponderosa pine by tree diameter. Note No. 63. Tucson, AZ: USDA Forest Service, Southwestern Forest and Range Experiment Station. 4 p.

Lezberg, A.L.; Battaglia, M.A.; Shepperd, W.D.; Schoettle, A.W. 2008. Decades-old silvicultural treatments influence surface wildfire severity and post-fire nitrogen availability in a ponderosa pine forest. Forest Ecology and Management. 255(1): 49-61. doi:10.1016/j.foreco.2007.08.019

Ligon, J.D. 1973. Foraging behavior of the white-headed woodpecker in Idaho. Auk. 90(4): 862-869. doi:10.2307/4084366

Lillebo, T. 2012. Restoring eastern Oregon’s dry forests: a practical guide for ecological restoration. Place of publication unknown: Oregon Wild. 15 p. Eastside_Restoration_Handbook

Lindenmayer, D.B.; Westgate, M.J.; Scheele, B.C.; Foster, C.N.; Blair, D.P. 2019. Key perspectives on early successional forests subject to stand-replacing disturbances. Forest Ecology and Management. 454: 117656 (10 p). doi:10.1016/j.foreco.2019.117656

Lindgren, W. 1901. The gold belt of the Blue Mountains of Oregon. In: Twenty-second annual report of the United States Geological Survey to the Secretary of the Interior; 1900-1901. Part II–ore deposits. Washington, DC: Government Printing Office: 551-776. Lindgren1901GoldBeltBlueMtns

Lindsay, A.; Oester, P.; Cole, E. 2009. Twenty-year response of ponderosa pine (*Pinus ponderosa*

Laws.) to treatment with hexazinone in northeastern Oregon. Western Journal of Applied Forestry. 24(3): 151-156. doi:10.1093/wjaf/24.3.151

Lindsay, A.A.; Johnston, J.D. 2020. Using historical reconstructions of moist mixed conifer forests to inform forest management on the Malheur National Forest. In: Pile, L.S.; Deal, R.L.; Dey, D.C.; Gwaze, D.; Kabrick, J.M.; Palik, B.; Schuler, T.M., comps. The 2019 National Silviculture Workshop: A focus on forest management-research partnerships. Gen. Tech. Rep. NRS-P-193. Madison, WI: USDA Forest Service, Northern Research Station: 23-33. https://www.fs.usda.gov/treesearch/pubs/60238

Linhart, Y.B.; Snyder, M.A.; Habeck, S.A. 1989. The influence of animals on genetic variability within ponderosa pine stands, illustrated by the effects of Abert's squirrel and porcupine. In: Tecle, A.; Covington, W.W.; Hamre, R.H., tech. coords. Multiresource management of ponderosa pine. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 141-148. https://archive.org/download/CAT10400419/CAT10400419.pdf

Littell, J.S.; McKenzie, D.; Peterson, D.L.; Westerling, A.L. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916-2003. Ecological Applications. 19(4): 1003-1021. doi:10.1890/07-1183.1

Littell, J.S.; McKenzie, D.; Wan, H.Y.; Cushman, S.A. 2018. Climate change and future wildfire in the western United States: An ecological approach to nonstationarity. Earth's Future. 6(8): 1097-1111. doi:10.1029/2018EF000878

Little, S.N.; Ward, F.R.; Sandberg, D.V. 1982. Duff reduction caused by prescribed fire on areas logged to different management intensities. Res. Note PNW-397. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p. https://www.fs.usda.gov/treesearch/pubs/7657

Liu, Z.; Wimberly, M.C. 2015. Climatic and landscape influences on fire regimes from 1984 to 2010 in the western United States. PLoS ONE. 10(10): e0140839. doi:10.1371/journal.pone.0140839

Liu, X.; Huey, L.G.; Yokelson, R.J.; Selimovic, V.; Simpson, I.J.; Müller, M.; Jimenez, J.L.; Campuzano-Jost, P.; Beyersdorf, A.J.; Blake, D.R.; Butterfield, Z.; Choi, Y.; Crounse, J.D.; Day, D.A.; Diskin, G.S.; Dubey, M.K.; Fortner, E.; Hanisco, T.F.; Hu, W.; King, L.E.; Kleinman, L.; Meinardi, S.; Mikoviny, T.; Onasch, T.B.; Palm, B.B.; Peischl, J.; Pollack, I.B.; Ryerson, T.B.; Sachse, G.W.; Sedlacek, A.J.; Shilling, J.E.; Springston, S.; St. Clair, J.M.; Tanner, D.J.; Teng, A.P.; Wennberg, P.O.; Wisthaler, A.; Wolfe, G.M. 2017. Airborne measurements of western U.S. wildfire emissions: Comparison with prescribed burning and air quality implications. Journal of Geophysical Research: Atmospheres. 122(11): 6108-6129. doi:10.1002/2016JD026315

Lloret, F.; Keeling, E.G.; Sala, A. 2011. Components of tree resilience: effects of successive low-growth episodes in old ponderosa pine forests. Oikos. 120(12): 1909-1920. doi:10.1111/j.1600-0706.2011.19372.x

Lomax, A.L. 1928. History of pioneer sheep husbandry in Oregon. Oregon Historical Quarterly. 29(2): 99-143. https://www.jstor.org/stable/20610411

Long, J.N.; Shaw, J.D. 2005. A density management diagram for even-aged ponderosa pine stands. Western Journal of Applied Forestry. 20(4): 205-215. doi:10.1093/wjaf/20.4.205

Long, J.N.; Smith, F.W. 1984. Relation between size and density in developing stands: a description and possible mechanisms. Forest Ecology and Management. 7(3): 191-206. doi:10.1016/0378-1127(84)90067-7

Long, J.N.; Smith, F.W. 2000. Restructuring the forest: goshawks and the restoration of southwestern ponderosa pine. Journal of Forestry. 98(8): 25-30. doi:10.1093/jof/98.8.25

Long, J.N.; Dean, T.J.; Roberts, S.D. 2004. Linkages between silviculture and ecology: examination of several important conceptual models. Forest Ecology and Management. 200(1-3): 249-261. doi:10.1016/j.foreco.2004.07.005

Long, R.A.; Rachlow, J.L.; Kie, J.G.; Vavra, M. 2008. Fuels reduction in a western coniferous forest: effects on quantity and quality of forage for elk. Rangeland Ecology and Management. 61(3): 302-313. doi:10.2111/07-046.1

Lopushinsky, W.; Beebe, T. 1976. Relationship of shoot-root ratio to survival and growth of outplanted Douglas-fir and ponderosa pine seedlings. Res. Note PNW-274. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p. https://archive.org/download/relationshipofsh274lopu/relationshipofsh274lopu.pdf

Lorenz, T.J.; Vierling, K.T.; Kozma, J.M.; Millard, J.E.; Raphael, M.G. 2015. Space use by white-headed woodpeckers and selection for recent forest disturbances. The Journal of Wildlife Management. 79(8): 1286-1297. doi:10.1002/jwmg.957

Lowdermilk, W.C. 1924. Erosion and floods in the Yellow River watershed. Journal of Forestry. 22(6): 11-18. doi:10.1093/jof/22.6.11

Lowdermilk, W.C. 1925. Factors affecting reproduction of Engelmann spruce. Journal of Agricultural Research. 30(11): 995-1009. https://naldc-legacy.nal.usda.gov/naldc/download.xhtml?id=IND43967040&content=PDF

Lowdermilk, W.C. 1928. The water cycle: A discussion of theoretical considerations and the point at which practical application may be made. Journal of Forestry. 26(3): 352-354. doi:10.1093/jof/26.3.352

Lowdermilk, W.C. 1930. Influence of forest litter on run-off, percolation, and erosion. Journal of Forestry. 28(4): 474-491. doi:10.1093/jof/28.4.474

Lowdermilk, W.C. 1934. The role of vegetation in erosion control and water conservation. Journal of Forestry. 32(5): 529-536. doi:10.1093/jof/32.5.529

Lowdermilk, W.C. 1953. Conquest of the land through 7,000 years. Agric. Infor. Bull. No. 99. Washington, DC: USDA Soil Conservation Service. 30 p. https://naldc.nal.usda.gov/download/CAT87210309/PDF

Lowdermilk, W.C.; Hamilton, G. 1922. The secondary species problem. Unpublished typescript report obtained from National Archives, College Park, Maryland; record group 95. USDA Forest Service. 29 p.

Lowdermilk, W.C.; Li, T.I. 1930. Forestry in denuded China. Annals of the American Academy of Political and Social Science. 152: 127-141. www.jstor.org/stable/1016547

Lowe, P.O.; Ffolliott, P.F.; Dieterich, J.H.; Patton, D.R. 1978. Determining potential wildlife benefits from wildfire in Arizona ponderosa pine forests. Gen. Tech. Rep. RM-52. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p. http://www.treesearch.fs.fed.us/pubs/37801

Lowell, E.C.; Todoroki, C.L.; Thomas, E. 2009. Comparing timber and lumber from plantation and natural stands of ponderosa pine. Western Journal of Applied Forestry. 24(3): 137-143. doi:10.1093/wjaf/24.3.137

Lowery, D.P. 1984. Ponderosa pine. . .an American wood. FS-254. Washington, DC: USDA Forest Service. 7 p.

Lucas, E. 1992. Bugged to death. Pacific Northwest. (March): 7, 10.

Lucas, E. 1993. Burning question: thinning and fire prescribed for pest-infested forests. Horizon Magazine. 4(3): 12-13, 28, 30-31.

Lucash, M.S.; Scheller, R.M.; J. Gustafson, E.; R. Sturtevant, B. 2017. Spatial resilience of forested landscapes under climate change and management. Landscape Ecology. 32(5): 953-969. doi:10.1007/s10980-017-0501-3

Lunan, J.S.; Habeck, J.R. 1973. The effects of fire exclusion on ponderosa pine communities in Glacier National Park, Montana. Canadian Journal of Forest Research. 3(4): 574-579. doi:10.1139/x73-084

Lundquist, J.E. 1995a. Characterizing disturbance in managed ponderosa pine stands in the Black Hills. Forest Ecology and Management. 74(1-3): 61-74. doi:10.1016/0378-1127(94)03516-Y

Lundquist, J.E. 1995b. Disturbance profile – a measure of small-scale disturbance patterns in ponderosa pine stands. Forest Ecology and Management. 74(1-3): 49-59. doi:10.1016/0378-1127(94)03515-X

Lundquist, J.E. 1995c. Pest interactions and canopy gaps in ponderosa pine stands in the Black Hills, South Dakota, USA. Forest Ecology and Management. 74(1-3): 37-48. doi:10.1016/0378-1127(94)03514-W

Lundquist, J.E.; Negron, J.F. 2000. Endemic forest disturbances and stand structure of ponderosa pine (Pinus ponderosa) in the Upper Pine Creek Research Natural Area, South Dakota, USA. Natural Areas Journal. 20(2): 126-132. https://www.jstor.org/stable/43911897

Lutz, J.A.; Larson, A.J.; Swanson, M.E.; Freund, J.A. 2012. Ecological importance of large-diameter trees in a temperate mixed-conifer forest. PLoS ONE. 7(5): e36131 (15 p). doi:10.1371/journal.pone.0036131

Lydersen, J.M.; North, M.P.; Knapp, E.E.; Collins, B.M. 2013. Quantifying spatial patterns of tree groups and gaps in mixed-conifer forests: Reference conditions and long-term changes following fire suppression and logging. Forest Ecology and Management. 304: 370-382. doi:10.1016/j.foreco.2013.05.023

Lydersen, J.M.; North, M.P.; Collins, B.M. 2014. Severity of an uncharacteristically large wildfire, the Rim Fire, in forests with relatively restored frequent fire regimes. Forest Ecology and Management. 328: 326-334. doi:10.1016/j.foreco.2014.06.005

Lynch, D.W. 1954. Growth of young ponderosa pine stands in the Inland Empire. Res. Paper No. 36. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 14 p.

Lynch, D.W. 1959. Effects of a wildfire on mortality and growth of young ponderosa pine trees. Res. Note No. 66. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 8 p. https://archive.org/download/effectsofwildfir66lync/effectsofwildfir66lync.pdf

Lynch, D.L.; Romme, W.H.; Floyd, M.L. 2000. Forest restoration in southwestern ponderosa pine. Journal of Forestry. 98(8): 17-24. doi:10.1093/jof/98.8.17

Lyon, L.J. 1971. Vegetal development following prescribed burning of Douglas-fir in south-central Idaho. Res. Pap. INT-105. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 30 p. https://archive.org/download/vegetaldevelopme105lyon/vegetaldevelopme105lyon.pdf

Ma, Z.; Steele, D.; Cutler, A.; Newcomb, K. 2020. Promoting sustainability in public natural-resource agencies: Insights from the USDA Forest Service. Journal of Forestry. 118(2): 105-123. doi:10.1093/jofore/fvz067

MacCleery, D.W. 1995. The way to a healthy future for National Forest ecosystems in the West: What role can silviculture and prescribed fire play? In: Eskew, L.G., comp. Forest health through silviculture: proceedings of the 1995 National Silviculture Workshop. Gen. Tech. Rep. RM-GTR-267. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO: 37-45. https://www.fs.usda.gov/treesearch/pubs/22037

MacCleery, D.W. 2011. American forests: a history of resiliency and recovery. FS-540. Durham, NC: Forest History Society. 71 p. https://foresthistory.org/wp-content/uploads/2016/12/American_Forests.pdf

MacFarlane, D.W.; Luo, A. 2009. Quantifying tree and forest bark structure with a bark-fissure index. Canadian Journal of Forest Research. 39(10): 1859-1870. doi:10.1139/X09-098

Macias Fauria, M.; Johnson, E.A. 2006. Large-scale climatic patterns control large lightning fire occurrence in Canada and Alaska forest regions. Journal of Geophysical Research. 111: G04008 (17 p). doi:10.1029/2006JG000181

MacKenzie, W.H.; Mahony, C.R. 2021. An ecological approach to climate change-informed tree species selection for reforestation. Forest Ecology and Management. 481: 118705 (17 p). doi:10.1016/j.foreco.2020.118705

MacKenzie, M.D.; DeLuca, T.H.; Sala, A. 2004. Forest structure and organic horizon analysis along a fire chronosequence in the low elevation forests of western Montana. Forest Ecology and Management. 203(1-3): 331-343. doi:10.1016/j.foreco.2004.08.003

MacKenzie, M.D.; DeLuca, T.H.; Sala, A. 2006. Fire exclusion and nitrogen mineralization in low elevation forests of western Montana. Soil Biology and Biochemistry. 38(5): 952-961. doi:10.1016/j.soilbio.2005.08.008

Madany, M.H.; West, N.E. 1983. Livestock grazing–fire regime interactions within montane forests of Zion National Park, Utah. Ecology. 64(4): 661-667. doi:10.2307/1937186

Maffei, H. 1992. Pruning guidelines for dwarf mistletoe infected ponderosa pine. Portland, OR: USDA Forest Service, Pacific Northwest Region, Deschutes National Forest. 13 p.

Maher, C.T.; Oja, E.; Marshall, A.; Cunningham, M.; Townsend, L.; Worley-Hood, G.; Robinson, L.R.; Margot, T.; Lyons, D.; Fety, S.; Schneider, E.E.; Jeronimo, S.M.A.; Churchill, D.J.; Larson, A.J. 2019. Real-time monitoring with a tablet app improves implementation of treatments to enhance forest structural diversity. Journal of Forestry. 117(3): 280-292. doi:10.1093/jofore/fvz003

Maki, T.E. 1940. Significance and applicability of seed maturity indices for ponderosa pine. Journal of Forestry. 38(1): 55-60. doi:10.1093/jof/38.1.55

Malkinson, D.; Wittenberg, L. 2011. Post fire induced soil water repellency—Modeling short and long-term processes. Geomorphology. 125(1): 186-192. doi:10.1016/j.geomorph.2010.09.014

Mallams, K.M. 2006. Results from an individual tree-based stocking control demonstration project around mature ponderosa pines ten years after treatment. Central Point, OR: USDA Forest Service, Pacific Northwest Region, Southwest Oregon Forest Insect and Disease Service Center. 9 p.

Mandzak, J.M.; Moore, J.A. 1994. The role of nutrition in the health of inland western forests. Journal of Sustainable Forestry. 2(1/2): 191-210. doi:10.1300/J091v02n01_09

Man, R.; Kayahara, G.J.; Dang, Q.-L.; Rice, J.A. 2009. A case of severe frost damage prior to budbreak in young conifers in northeastern Ontario: Consequence of climate change? Forestry Chronicle. 85(3): 453-462. doi:10.5558/tfc85453-3

Mann, C.C. 2006. 1491: new revelations of the Americas before Columbus. New York: Vintage Books. 538 p. isbn:1-4000-3205-9

Mannan, R.W.; Meslow, E.C. 1984. Bird populations and vegetation characteristics in managed and old-growth forests, northeastern Oregon. Journal of Wildlife Management. 48(4): 1219-1238. doi:10.2307/3801783

Mark, W.R.; Hawksworth, F.G. 1974. How important are bole infections in spread of ponderosa pine dwarf mistletoe? Journal of Forestry. 72(3): 146-147. doi:10.1093/jof/72.3.146

Maron, M.; Simmonds, J.S.; Watson, J.E.M.; Sonter, L.J.; Bennun, L.; Griffiths, V.F.; Quétier, F.; von Hase, A.; Edwards, S.; Rainey, H.; Bull, J.W.; Savy, C.E.; Victurine, R.; Kiesecker, J.; Puydarrieux, P.; Stevens, T.; Cozannet, N.; Jones, J.P.G. 2020. Global no net loss of natural ecosystems. Nature Ecology & Evolution. 4(1): 46-49. doi:10.1038/s41559-019-1067-z

Marr, J.W. 1967. Ecosystems of the east slope of the Front Range in Colorado. Boulder, CO: Colorado Associated University Press. 134 p. https://scholar.colorado.edu/cgi/viewcontent.cgi?article=1020&context=sbio

Marsden, M.A. 1983. Modeling the effect of wildfire frequency on forest structure and succession in the northern Rocky Mountains. Journal of Environmental Management. 16: 45-62.

Marsden, M.A.; Shaw, C.G., III; Morrison, M. 1993. Simulation of management options for stands of southwestern ponderosa pine attacked by Armillaria root disease and dwarf mistletoe. Gen. Tech. Rep. RM-308. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 5 p. https://archive.org/download/IND20363814/IND20363814.pdf

Marsh, A.; Mawdsley, J.; Negra, C. 2009. Forest observations and indicators needed to respond to climate change. Journal of Forestry. 107(5): 231-232. doi:10.1093/jof/107.5.231

Martin, C.S. 1940. Forest resources, cutting practices, and utilization problems in the pine region of the Pacific Northwest. Journal of Forestry. 38(9): 681-685. doi:10.1093/jof/38.9.681

Martinez-Meier, A.; Fernández, M.E.; Dalla-Salda, G.; Gyenge, J.; Licata, J.; Rozenberg, P. 2015. Ecophysiological basis of wood formation in ponderosa pine: Linking water flux patterns with wood microdensity variables. Forest Ecology and Management. 346: 31-40. doi:10.1016/j.foreco.2015.02.021

Martinson, E.J.; Omi, P.N. 2013. Fuel treatments and fire severity: A meta-analysis. Res. Pap. RMRS-RP-103WWW. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 38 p. http://www.treesearch.fs.fed.us/pubs/43632

Maruoka, K.R. 1994. Fire history of *Pseudotsuga menziesii* and *Abies grandis* stands in the Blue Mountains of Oregon and Washington. M.S. thesis. Seattle, WA: University of Washington, College of Forest Resources. 73 p.

Maser, C.; Anderson, R.G.; Cromack, R., Jr.; Williams, J.T.; Martin, R.E. 1979. Dead and down woody material. In: Thomas, J.W., tech. ed. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. Agricul. Handb. No. 553. Washington, DC: USDA Forest Service: 78-95.

Mason, R.R.; Wickman, B.E. 1988. The Douglas-fir tussock moth in the interior Pacific Northwest. In: Berryman A.A., ed. Dynamics of forest insect populations. [Place of publication unknown]: Plenum Publishing Corporation: 179-209.

Mason, R.R.; Wickman, B.E. 1994. Procedures to reduce landscape hazard from insect outbreaks. In: Everett, R.L., comp. Volume IV: restoration of stressed sites, and processes. Gen. Tech. Rep. PNW-GTR-330. Portland, OR: USDA Forest Service, Pacific Northwest Research Station: 20-21. https://www.fs.usda.gov/treesearch/pubs/6939

Mason, G.J.; Baker, T.T.; Cram, D.S.; Boren, J.C.; Fernald, A.G.; VanLeeuwen, D.M. 2009. Mechanical fuel treatment effects on vegetation in a New Mexico dry mixed conifer forest. Forest Ecology and Management. 257(3): 868-875. doi:10.1016/j.foreco.2008.10.017

Mast, J.N.; Fulé, P.Z.; Moore, M.M.; Covington, W.W.; Waltz, A.E.M. 1999. Restoration of presettlement age structure of an Arizona ponderosa pine forest. Ecological Applications. 9(1): 228-239. doi:10.1890/1051-0761(1999)009[0228:ROPASO]2.0.CO;2

Mata, S.A., Jr. 1972. Accuracy of determining mountain pine beetle attacks in ponderosa pine utilizing pitch tubes, frass, and entrance holes. Res. Note RM-222. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p. Accuracy_of_Determining_Mountain_Pine_Be

Matonis, M.S.; Binkley, D. 2018. Not just about the trees: Key role of mosaic-meadows in restoration of ponderosa pine ecosystems. Forest Ecology and Management. 411: 120-131. doi:10.1016/j.foreco.2018.01.019

Matz, Fred A. 1932. Descriptive report, Camas Creek timber survey project, Umatilla National Forest. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. Portland, OR: USDA Forest Service, North Pacific District. 71 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5376658.pdf

Maxwell, W.G.; Ward, F.R. 1976. Photo series for quantifying forest residues in the ponderosa pine type, ponderosa pine and associated species type, lodgepole pine type. Gen. Tech. Rep. PNW-52. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 73 p.

Maxwell, J.D.; Call, A.; St. Clair, S.B. 2019. Wildfire and topography impacts on snow accumulation and retention in montane forests. Forest Ecology and Management. 432: 256-263. doi:10.1016/j.foreco.2018.09.021

Mazurek, M.J.; Zielinski, W.J. 2004. Individual legacy trees influence vertebrate wildlife diversity in commercial forests. Forest Ecology and Management. 193(3): 321-334. doi:10.1016/j.foreco.2004.01.013

McAvoy, D. 2008. World's oldest ponderosa pine found in Utah fire study. Utah Forest News. 12(1): 1-4.

McCaffrey, S.; Graham, R. 2007. Science information for informing forest fuel management in the dry forests of the western United States. Journal of Forestry. 105(2): 73-76. doi:10.1093/jof/105.2.73

McCaffrey, S.; Toman, E.; Stidham, M.; Shindler, B. 2013. Social science research related to wildfire management: an overview of recent findings and future research needs. International Journal of Wildland Fire. 22(1): 15-24. doi:10.1071/WF11115

McCambridge, W.F. 1964. Emergence period of Black Hills beetles from ponderosa pine in the central Rocky Mountains. Res. Note RM-32. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/CAT31302176/CAT31302176.pdf

McCambridge, W.F. 1974. Identifying ponderosa pines infested with mountain pine beetles. Res. Note RM-273. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range

Experiment Station. 2 p. https://www.fs.usda.gov/treesearch/pubs/7375

McCambridge, W.F. 1980. Some mountain pine beetle infestation characteristics in dwarf mistletoe-infected and uninfected ponderosa pine. Res. Note RM-391. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 2 p. Some_Mountain_Pine_Beetle_Infestation_Ch

McCambridge, W.F.; Stevens, R.E. 1982. Effectiveness of thinning ponderosa pine stands in reducing mountain pine beetle-caused tree losses in the Black Hills – preliminary observations. Res. Note RM-414. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p. https://archive.org/download/IND83042435/IND83042435.pdf

McCambridge, W.F.; Morris, M.J.; Edminster, C.B. 1982a. Herbage production under ponderosa pine killed by the mountain pine beetle in Colorado. Res. Note RM-416. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. Herbage_Production_Under_Ponderosa_Pine

McCambridge, W.F.; Hawksworth, F.G.; Edminster, C.B.; Laut, J.G. 1982b. Ponderosa pine mortality resulting from a mountain pine beetle outbreak. Res. Paper RM-235. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p. https://www.fs.usda.gov/treesearch/pubs/30385

McCaskill, G.L. 2019. The Hungry Bob fire & fire surrogate study: A 20-year evaluation of the treatment effects. Forests. 10(1): 15 (12 p). doi:10.3390/f10010015

McCollum, D.W.; Lundquist, J.E. 2019. Bark beetle infestation of western US forests: A context for assessing and evaluating impacts. Journal of Forestry. 117(2): 171-177. doi:10.1093/jofore/fvy041

McConnell, B.R.; Smith, J.G. 1970. Response of understory vegetation to ponderosa pine thinning in eastern Washington. Journal of Range Management. 23(3): 208-212. https://journals.uair.arizona.edu/index.php/jrm/article/download/5809/5419

McConnell, B.R.; Smith, J.G. 1971. Effect of ponderosa pine needle litter on grass seedling survival. Res. Note PNW-155. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p. https://www.fs.usda.gov/treesearch/pubs/26376

McCullough, D.G.; Wagner, M.R. 1987. Evaluation of four techniques to assess vigor of water-stressed ponderosa pine. Canadian Journal of Forest Research. 17(2): 138-145. doi:10.1139/x87-025

McCune, B. 1983. Fire frequency reduced two orders of magnitude in the Bitterroot canyons, Montana. Canadian Journal of Forest Research. 13(2): 212-218. doi:10.1139/x83-030

McCune, B. 1986. Root competition in a low-elevation grand fir forest in Montana: a trenching experiment. Northwest Science. 60(1): 52-54. http://hdl.handle.net/2376/1786

McDonald, P.M. 1976. Inhibiting effect of ponderosa pine seed trees on seedling growth. Journal of Forestry. 74(4): 220-224. doi:10.1093/jof/74.4.220

McDonald, P.M. 1986. Grasses in young conifer plantations – hindrance and help. Northwest Science. 60(4): 271-278. http://hdl.handle.net/2376/1811

McDonald, P.M.; Everest, G.A. 1996. Response of young ponderosa pines, shrubs, and grasses to two release treatments. Res. Paper PSW-RP-419. Berkeley, CA: USDA Forest Service, Pacific Southwest Research Station. 7 p. https://www.fs.usda.gov/treesearch/pubs/6896

McDonald, P.M.; Fiddler, G.O. 1990. Ponderosa pine seedlings and competing vegetation: ecology, growth, and cost. Res. Paper PSW-199. Berkeley, CA: USDA Forest Service, Pacific

Southwest Research Station. 10 p. https://www.fs.usda.gov/treesearch/pubs/31477

McDonald, P.M.; Fiddler, G.O. 1999. Effect of cattle grazing, seeded grass, and an herbicide on ponderosa pine seedling survival and growth. Res. Paper PSW-RP-242. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 15 p. https://www.fs.usda.gov/treesearch/pubs/6925

McDonald, P.M.; Fiddler, G.O. 2007. Development of vegetation in a young ponderosa pine plantation: effect of treatment duration and time since disturbance. Res. Pap. PSW-RP-251. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 23 p. https://www.fs.usda.gov/treesearch/pubs/28578

McDonald, P.M.; Skinner, C.N.; Fiddler, G.O. 1992. Ponderosa pine needle length: an early indicator of release treatment effectiveness. Canadian Journal of Forest Research. 22(5): 761-764. doi:10.1139/x92-103

McDonald, P.M.; Fiddler, G.; Ritchie, M.; Anderson, P. 2009. Naturally seeded versus planted ponderosa pine seedlings in group-selection openings. Western Journal of Applied Forestry. 24(1): 48-54. doi:10.1093/wjaf/24.1.48

McDowell, N.; Brooks, J.R.; Fitzgerald, S.A.; Bond, B.J. 2003. Carbon isotope discrimination and growth response of old *Pinus ponderosa* trees to stand density reductions. Plant, Cell and Environment. 26(4): 631-644. doi:10.1046/j.1365-3040.2003.00999.x

McDowell, N.G.; Adams, H.D.; Bailey, J.D.; Kolb, T.E. 2007. The role of stand density on growth efficiency, leaf area index, and resin flow in southwestern ponderosa pine forests. Canadian Journal of Forest Research. 37(2): 343-355. doi:10.1139/X06-233

McGlone, C.M.; Egan, D. 2009. The role of fire in the establishment and spread of nonnative plants in Arizona ponderosa pine forests: a review. Journal of the Arizona-Nevada Academy of Science. 41(2): 75-86. doi: 10.2181/036.041.0206

McGlone, C.M.; Springer, J.D.; Laughlin, D.C. 2009. Can pine forest restoration promote a diverse and abundant understory and simultaneously resist nonnative invasion? Forest Ecology and Management. 258(12): 2638-2646. doi:10.1016/j.foreco.2009.09.024

McHugh, C.W.; Kolb, T.E. 2003. Ponderosa pine mortality following fire in northern Arizona. International Journal of Wildland Fire. 12(1): 7-22. doi:10.1071/WF02054

McIver, J.D.; Ottmar, R. 2007. Fuel mass and stand structure after post-fire logging of a severely burned ponderosa pine forest in northeastern Oregon. Forest Ecology and Management. 238(1-3): 268-279. doi:10.1016/j.foreco.2006.10.021

McIver, J.D.; Ottmar, R. 2018. Fuel mass and stand structure 13 years after logging of a severely burned ponderosa pine forest in northeastern Oregon, U.S.A. Forest Ecology and Management. 424: 505-518. doi:10.1016/j.foreco.2018.04.047

McIver, J.D.; Starr, L. 2000. Environmental effects of postfire logging: literature review and annotated bibliography. Gen. Tech. Rep. PNW-GTR-486. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 72 p. https://www.fs.usda.gov/treesearch/pubs/2955

McIver, J.; Weatherspoon, P.; Edminster, C.B. 2001. Alternative ponderosa pine restoration treatments in the western United States. In: Vance, R.K.; Edminster, C.B.; Covington, W.W.; Blake, J.A., comps. Ponderosa pine ecosystems restoration and conservation: steps toward stewardship. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 104-109. https://www.fs.usda.gov/treesearch/pubs/46681

McIver, J.D.; Adams, P.W.; Doyal, J.A.; Drews, E.S.; Hartsough, B.R.; Kellogg, L.D.; Niwa, C.G.;

Ottmar, R.; Peck, R.; Tarratoot, M.; Torgersen, T.; Youngblood, A. 2003. Environmental effects and economics of mechanized logging for fuel reduction in northeastern Oregon mixed-conifer stands. Western Journal of Applied Forestry. 18(4): 238-249. doi:10.1093/wjaf/18.4.238

McIver, J.; Youngblood, A.; Stephens, S.L. 2009. The national Fire and Fire Surrogate study: ecological consequences of fuel reduction methods in seasonally dry forests. Ecological Applications. 19(2): 283-284. doi:10.1890/07-1785.1

McIver, J.D.; Stephens, S.L.; Agee, J.K.; Barbour, J.; Boerner, R.E.J.; Edminster, C.B.; Erickson, K.L.; Farris, K.L.; Fettig, C.J.; Fiedler, C.E.; Haase, S.; Hart, S.C.; Keeley, J.E.; Knapp, E.E.; Lehmkuhl, J.F.; Moghaddas, J.J.; Otrosina, W.; Outcalt, K.W.; Schwilk, D.W.; Skinner, C.N.; Waldrop, T.A.; Weatherspoon, C.P.; Yaussy, D.A.; Youngblood, A.; Zack, S. 2013. Ecological effects of alternative fuel-reduction treatments: highlights of the National Fire and Fire Surrogate study (FFS). International Journal of Wildland Fire. 22(1): 63-82. doi:10.1071/WF11130

McKeever, D.G. 1942. Results of direct seeding of ponderosa pine in the northern Rocky Mountain region. Res. Note No. 20. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 6 p. https://archive.org/download/CAT31013584/CAT31013584.pdf

McKenzie, D.; Peterson, D.L.; Agee, J.K. 2000. Fire frequency in the interior Columbia River basin: building regional models from fire history data. Ecological Applications. 10(5): 1497-1516. doi:10.1890/1051-0761(2000)010[1497:FFITIC]2.0.CO;2

McLean, A. 1969. Fire resistance of forest species as influenced by root systems. Journal of Range Management. 22(2): 120-122. https://journals.uair.arizona.edu/index.php/jrm/article/download/5682/5292

McLean, H.E. 1992. The Blue Mountains: forest out of control. American Forests. 98(9/10): 32, 34-35, 58, 61.

McLeod, S.D.; Running, S.W. 1988. Comparing site quality indices and productivity in ponderosa pine stands of western Montana. Canadian Journal of Forest Research. 18(3): 346-352. doi:10.1139/x88-052

McMahon, S.M.; Arellano, G.; Davies, S.J. 2019. The importance and challenges of detecting changes in forest mortality rates. Ecosphere. 10(2): e02615 (10 p). doi:10.1002/ecs2.2615

McMinn, R.G. 1952. The role of soil drought in the distribution of vegetation in the northern Rocky Mountains. Ecology. 33(1): 1-15. doi:10.2307/1931247

McTague, J.P.; Stansfield, W.F. 1994. Stand and tree dynamics of uneven-aged ponderosa pine. Forest Science. 40(2): 289-302. doi:10.1093/forestscience/40.2.289

McTague, J.P.; Tinus, R.W. 1996. The effects of seedling quality and forest site weather on field survival of ponderosa pine. Tree Planters' Notes. 47(1): 16-23. the-effects-of-seedling-quality-and-forest-site-weather-on-field-survival-of-ponderosa-pine

Meddens, A.J.H.; Kolden, C.A.; Lutz, J.A. 2016. Detecting unburned areas within wildfire perimeters using Landsat and ancillary data across the northwestern United States. Remote Sensing of Environment. 186: 275-285. doi:10.1016/j.rse.2016.08.023

Medler, M.J.; Ofren, R. 2001. Evaluating the relationships between fire induced canopy mortality and pre?fire multispectral patterns. Geocarto International. 16(4): 83-90. doi:10.1080/10106040108542217

Megahan, W.F.; Steele, R. 1987. An approach for predicting snow damage to ponderosa pine plantations. Forest Science. 33(2): 485-503. doi:10.1093/forestscience/33.2.485

Megahan, W.F.; Steele, R. 1988. A field guide for predicting snow damage to ponderosa pine plantations. Res. Note INT-385. Ogden, UT: USDA Forest Service, Intermountain Research Station. 9 p. https://archive.org/download/fieldguideforpre385mega/fieldguideforpre385mega.pdf

Mehringer, P.J., Jr. 1997. Late Holocene fire and forest history from Lost Lake, Umatilla National Forest, Blue Mountains, Oregon. Challenge Cost-Share Agreement No. CCS-06-95-04-058. John Day, OR: USDA Forest Service, Malheur National Forest. 29 p.

Mehringer, P.J., Jr.; Wigand, P.E. 1987. Western juniper in the Holocene. In: Everett, R.L., comp. Proceedings–pinyon-juniper conference. Gen. Tech. Rep. INT-215. Ogden, UT: USDA Forest Service, Intermountain Research Station: 109-119. https://www.fs.usda.gov/treesearch/pubs/50072

Mellen-McLean, K.; Wales, B.; Bresson, B. 2013. A conservation assessment for the white-headed woodpecker (*Picoides albolarvatus*). Portland, OR: USDA Forest Service, Region 6; U.S. Department of the Interior, Bureau of Land Management, Oregon and Washington. 41 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5434074.pdf

Mercer, D.E.; Prestemon, J.P.; Butry, D.T.; Pye, J.M. 2007. Evaluating alternative prescribed burning policies to reduce net economic damages from wildfire. American Journal of Agricultural Economics. 89(1): 63-77. doi:10.1111/j.1467-8276.2007.00963.x

Merrill, E.H.; Mayland, H.F.; Peek, J.M. 1980. Effects of a fall wildfire on herbaceous vegetation on xeric sites in the Selway-Bitterroot Wilderness, Idaho. Journal of Range Management. 33(5): 363-367. https://journals.uair.arizona.edu/index.php/jrm/article/download/7088/6700

Merrill, E.H.; Mayland, H.F.; Peek, J.M. 1982. Shrub responses after fire in an Idaho ponderosa pine community. Journal of Wildlife Management. 46(2): 496-502. doi:10.2307/3808665

Merrill, L.M.; Hawksworth, F.G.; Jacobi, W.R. 1987. Frequency and severity of ponderosa pine dwarf mistletoe in relation to habitat type and topography in Colorado. Plant Disease Reporter. 71(4): 342-344. doi:10.1094/PD-71-0342

Merschel, A.G. 2012. Mixed-conifer forests of central Oregon: structure, composition, history of establishment, and growth. M.S. Thesis. Corvallis, OR: Oregon State University. 149 p. http://scholarsarchive.library.oregonstate.edu/xmlui/handle/1957/36236

Merschel, A.G.; Spies, T.A.; Heyerdahl, E.K. 2014. Mixed-conifer forests of central Oregon: effects of logging and fire exclusion vary with environment. Ecological Applications. 24(7): 1670-1688. doi:10.1890/13-1585.1

Merschel, A.G.; Heyerdahl, E.K.; Spies, T.A.; Loehman, R.A. 2018. Influence of landscape structure, topography, and forest type on spatial variation in historical fire regimes, Central Oregon, USA. Landscape Ecology. 33(7): 1195-1209. doi:10.1007/s10980-018-0656-6

Merschel, A.; Vora, R.S.; Spies, T. 2019. Conserving dry old-growth forest in central Oregon, USA. Journal of Forestry. 117(2): 128-135. doi:10.1093/jofore/fvy085

Messier, C.; Puettmann, K.J.; Coates, K.D. 2013. Managing forests as complex adaptive systems: Building resilience to the challenge of global change. Earthscan Forest Library. New York: Routledge. 353 p. isbn:978-0-415-51977-9

Metlen, K.L.; Fiedler, C.E. 2006. Restoration treatment effects on the understory of ponderosa pine/Douglas-fir forests in western Montana, USA. Forest Ecology and Management. 222(1–3): 355-369. doi:10.1016/j.foreco.2005.10.037

Metlen, K.L.; Fiedler, C.E.; Youngblood, A. 2004. Understory response to fuel reduction treatments in the Blue Mountains of northeastern Oregon. Northwest Science. 78(3): 175-185. https://www.fs.usda.gov/treesearch/pubs/20383

Metlen, K.L.; Skinner, C.N.; Olson, D.R.; Nichols, C.; Borgias, D. 2018. Regional and local controls on historical fire regimes of dry forests and woodlands in the Rogue River Basin, Oregon, USA. Forest Ecology and Management. 430: 43-58. doi:10.1016/j.foreco.2018.07.010

Meyer, W.H. 1930. A method of constructing growth tables for selectively cut stands of western yellow pine. Journal of Forestry. 28(8): 1076-1084. doi:10.1093/jof/28.8.1076

Meyer, W.H. 1932. Growth cycles in the western yellow pine region of Oregon and Washington. Journal of Forestry. 30(4): 507-508. doi:10.1093/jof/30.4.499

Meyer, W.H. 1934. Growth in selectively cut ponderosa pine forests of the Pacific Northwest. Tech. Bull. No. 407. Washington, DC: U.S. Department of Agriculture. 64 p. https://naldc.nal.usda.gov/download/CAT86200401/PDF

Meyer, W.H. 1961. Yield of even-aged stands of ponderosa pine. Washington, DC: U.S. Department of Agriculture. 59 p. http://andrewsforest.oregonstate.edu/pubs/pdf/pub4109.pdf

Meyer, C.L.; Sisk, T.D. 2001. Butterfly response to microclimatic conditions following ponderosa pine restoration. Restoration Ecology. 9(4): 453-461. doi:10.1046/j.1526-100X.2001.94014.x

Meyer, C.L.; Sisk, T.D.; Covington, W.W. 2001. Microclimatic changes induced by ecological restoration of ponderosa pine forests in northern Arizona. Restoration Ecology. 9(4): 443-452. doi:10.1046/j.1526-100X.2001.94013.x

Michaletz, S.T.; Johnson, E.A. 2008. A biophysical process model of tree mortality in surface fires. Canadian Journal of Forest Research. 38(7): 2013-2029. doi:10.1139/X08-024

Miesel, J.R.; Boerner, R.E.J.; Skinner, C.N. 2009. Mechanical restoration of California mixed-conifer forests: does it matter which trees are cut? Restoration Ecology. 17(6): 784-795. doi:10.1111/j.1526-100X.2008.00414.x

Mildrexler, D.J.; Berner, L.T.; Law, B.E.; Birdsey, R.A.; Moomaw, W.R. 2020. Large trees dominate carbon storage in forests east of the Cascade crest in the United States Pacific Northwest. Frontiers in Forests and Global Change. 3(127): 594274 (15 p). doi:10.3389/ffgc.2020.594274

Miles, C. 1941. Growth of Douglas fir in eastern Idaho. Journal of Forestry. 39(8): 689-692. doi:10.1093/jof/39.8.689

Millar, C.I.; Stephenson, N.L. 2015. Temperate forest health in an era of emerging megadisturbance. Science. 349(6250): 823-826. doi:10.1126/science.aaa9933

Millar, C.I.; Woolfenden, W.B. 1999. The role of climate change in interpreting historical variability. Ecological Applications. 9(4): 1207-1216. doi:10.1890/1051-0761(1999)009[1207:TROCCI]2.0.CO;2

Miller, J.M. 1926. The western pine beetle control problem. Journal of Forestry. 24(8): 897-910. doi:10.1093/jof/24.8.897

Miller, E.A.; Halpern, C.B. 1998. Effects of environment and grazing disturbance on tree establishment in meadows of the central Cascade Range, Oregon, USA. Journal of Vegetation Science. 9(2): 265-282. doi:10.2307/3237126

Miller, J.M.; Patterson, J.E. 1927. Preliminary studies on the relation of fire injury to bark-beetle attack in western yellow pine. Journal of Agricultural Research. 34(7): 597-613. https://naldc-legacy.nal.usda.gov/naldc/download.xhtml?id=IND43967307&content=PDF

Miller, R.F.; Rose, J.A. 1995. Historic expansion of *Juniperus occidentalis* (western juniper) in southeastern Oregon. Great Basin Naturalist. 55(1): 37-45. https://scholarsarchive.byu.edu/gbn/vol55/iss1/4

Miller, E.M.; Seastedt, T.R. 2009. Impacts of woodchip amendments and soil nutrient availability on understory vegetation establishment following thinning of a ponderosa pine forest. Forest Ecology and Management. 258(3): 263-272. doi:10.1016/j.foreco.2009.04.011

Miller, C.; Urban, D.L. 1999. Interactions between forest heterogeneity and surface fire regimes in the southern Sierra Nevada. Canadian Journal of Forest Research. 29(2): 202-212. doi:10.1139/x98-188

Miller, C.; Urban, D.L. 2000a. Connectivity of forest fuels and surface fire regimes. Landscape Ecology. 15(2): 145-154. doi:10.1023/A:1008181313360

Miller, C.; Urban, D.L. 2000b. Modeling the effects of fire management alternatives on Sierra Nevada mixed-conifer forests. Ecological Applications. 10(1): 85-94. doi:10.1890/1051-0761(2000)010[0085:MTEOFM]2.0.CO;2

Miller, R.F.; Angell, R.F.; Eddleman, L.E. 1987. Water use by western juniper. In: Everett, R.L., comp. Proceedings–pinyon-juniper conference. Gen. Tech. Rep. INT-215. Ogden, UT: USDA Forest Service, Intermountain Research Station: 418-422. https://www.fs.usda.gov/treesearch/pubs/50072

Miller, R.F.; Bates, J.D.; Svejcar, T.J.; Pierson, F.B.; Eddleman, L.E. 2005. Biology, ecology, and management of western juniper (*Juniperus occidentalis*). Tech. Bull. 152. Corvallis, OR: Oregon State University, Agricultural Experiment Station. 77 p. http://juniper.oregonstate.edu/bibliography/documents/phpQ65pOk_tb152.pdf

Miller, R.F.; Bates, J.D.; Svejcar, T.J.; Pierson, F.B.; Eddleman, L.E. 2007. Western juniper field guide: asking the right questions to select appropriate management actions. Circ. 1321. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey. 61 p. http://pubs.usgs.gov/circ/1321/pdf/circ1321.pdf

Miller, J.; Safford, H.; Crimmins, M.; Thode, A. 2009. Quantitative evidence for increasing forest fire severity in the Sierra Nevada and southern Cascade Mountains, California and Nevada, USA. Ecosystems. 12:16-32. doi:10.1007/s10021-008-9201-9

Miller, S.; Jain, T.; Battaglia, M.A.; Han, H.-S.; Graham, R.T.; Keyes, C.R.; Fried, J.S.; Sandquist, J.E. 2014. Revisiting disturbance: A new guide for keeping dry mixed conifer forests healthy through fuel management. Science You Can Use Bulletin, Issue 9. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 12 p. https://www.fs.usda.gov/treesearch/pubs/47766

Milne, K.A.; Hejl, S.J. 1989. Nest-site characteristics of white-headed woodpeckers. Journal of Wildlife Management. 53(1): 50-55. doi:10.2307/3801305

Milner, K.S. 1992. Site index and height growth curves for ponderosa pine, western larch, lodgepole pine, and Douglas-fir in western Montana. Western Journal of Applied Forestry. 7(1): 9-14. doi:10.1093/wjaf/7.1.9

Ministry of Agriculture and Forestry. 2009. Standards and guidelines for the sustainable management of indigenous forests. Fourth ed. Wellington, New Zealand: Ministry of Agriculture and Forestry, MAF Policy. 219 p.

Minor, C.O. 1964. Site-index curves for young-growth ponderosa pine in northern Arizona. Res. Note RM-37. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Minto, J. 1902. Sheep husbandry in Oregon: The pioneer era of domestic sheep husbandry. Quarterly of the Oregon Historical Society. 3(3): 219-247. https://www.jstor.org/stable/20609532

Misson, L.; Tang, J.; Xu, M.; McKay, M.; Goldstein, A. 2005. Influences of recovery from clear-cut, climate variability, and thinning on the carbon balance of a young ponderosa pine plantation. Agricultural and Forest Meteorology. 130(3-4): 207-222. doi:10.1016/j.agrformet.2005.04.001

Mitchell, R.G.; Martin, R.E. 1980. Fire and insects in pine culture of the Pacific Northwest. In: Martin, R.E.; Edmonds, R.L.; Faulkner, D.A.; Harrington, J.B.; Fuquay, D.M.; Stocks, B.J.; Barr, S., eds. Proceedings: sixth conference on fire and forest meteorology. Washington, DC: Society of American Foresters: 182-190.

Mitchell, J.E.; Popovich, S.J. 1997. Effectiveness of basal area for estimating canopy cover of ponderosa pine. Forest Ecology and Management. 95(1): 45-51. doi:10.1016/S0378-1127(97)00002-9

Mitchell, R.G.; Waring, R.H.; Pitman, G.B. 1983. Thinning lodgepole pine increases tree vigor and resistance to mountain pine beetle. Forest Science. 29(1): 204-211. doi:10.1093/forestscience/29.1.204

Mitchell, R.J.; Palik, B.J.; Hunter, M.L., Jr. 2002. Natural disturbance as a guide to silviculture. Forest Ecology and Management. 155(1-3): 315-317. doi:10.1016/S0378-1127(01)00568-0

Mitchell, S.R.; Harmon, M.E.; O'Connell, K.E.B. 2009. Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems. Ecological Applications. 19(3): 643-655. doi:10.1890/08-0501.1

Mobley, C.M.; Eldridge, M. 1992. Culturally modified trees in the Pacific Northwest. Arctic Anthropology. 29(2): 91-110. https://www.jstor.org/stable/40316316

Mockta, T.K.; Fulé, P.Z.; Sánchez Meador, A.; Padilla, T.; Kim, Y.-S. 2018. Sustainability of culturally important teepee poles on Mescalero Apache Tribal Lands: Characteristics and climate change effects. Forest Ecology and Management. 430: 250-258. doi:10.1016/j.foreco.2018.08.017

Moeck, H.A.; Wood, D.L.; Lindahl, K.Q., Jr. 1981. Host selection behavior of bark beetles (Coleoptera: Scolytidae) attacking *Pinus ponderosa*, with special emphasis on the western pine beetle, *Dendroctonus brevicomis*. Journal of Chemical Ecology. 7(1): 49-83. doi:10.1007/BF00988635

Moghaddas, J.J.; Craggs, L. 2007. A fuel treatment reduces fire severity and increases suppression efficiency in a mixed conifer forest. International Journal of Wildland Fire. 16(6): 673-678. doi:10.1071/WF06066

Moghaddas, E.E.Y.; Stephens, S.L. 2007. Thinning, burning, and thin-burn fuel treatment effects on soil properties in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management. 250(3): 156-166. doi:10.1016/j.foreco.2007.05.011

Moir, W.H. 1966. Influence of ponderosa pine on herbaceous vegetation. Ecology. 47(6): 1045-1048. doi:10.2307/1935654

Moir, W.H.; Dieterich, J.H. 1988. Old-growth ponderosa pine from succession in pine-bunchgrass forests in Arizona and New Mexico. Natural Areas Journal. 8(1): 17-24. https://www.jstor.org/stable/43910967

Moir, W.H.; Geils, B.W.; Benoit, M.A.; Scurlock, D. 1997. Ecology of southwestern ponderosa pine forests. In: Block, W.M.; Finch, D.M., tech. eds. Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-292. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 3-27. https://www.fs.usda.gov/treesearch/pubs/21686

Mollohan, C.; Brady, W.W.; LeCount, A.L. 1989. Habitat use of an Arizona ponderosa pine-mixed conifer forest by female black bears. Western Journal of Applied Forestry. 4(1): 6-10. doi:10.1093/wjaf/4.1.6

Monleon, V.J.; Cromack, K., Jr. 1996. Long-term effects of prescribed underburning on litter decomposition and nutrient release in ponderosa pine stands in central Oregon. Forest Ecology and Management. 81(1-3): 143-152. doi:10.1016/0378-1127(95)03658-X

Monleon, V.J.; Cromack, K., Jr.; Landsberg, J.D. 1997. Short- and long-term effects of prescribed underburning on nitrogen availability in ponderosa pine stands in central Oregon. Canadian Journal of Forest Research. 27(3): 369-378. doi:10.1139/x96-184

Monnig, E.; Byler, J. 1992. Forest health and ecological integrity in the northern Rockies. FPM Rep. 92-7. Missoula, MT: USDA Forest Service, Northern Region. 18 p.

Monroe, M.E.; Converse, S.J. 2006. The effects of early season and late season prescribed fires on small mammals in a Sierra Nevada mixed conifer forest. Forest Ecology and Management. 236(2-3): 229-240. doi:10.1016/j.foreco.2006.09.008

Monsanto, P.G.; Agee, J.K. 2008. Long-term post-wildfire dynamics of coarse woody debris after salvage logging and implications for soil heating in dry forests of the eastern Cascades, Washington. Forest Ecology and Management. 255(12): 3952-3961. doi:10.1016/j.foreco.2008.03.048

Montes-Helu, M.C.; Kolb, T.; Dore, S.; Sullivan, B.; Hart, S.C.; Koch, G.; Hungate, B.A. 2009. Persistent effects of fire-induced vegetation change on energy partitioning and evapotranspiration in ponderosa pine forests. Agricultural and Forest Meteorology. 149(3-4): 491-500. doi:10.1016/j.agrformet.2008.09.011

Mooney, K.A.; Linhart, Y.B.; Snyder, M.A. 2011. Masting in ponderosa pine: comparisons of pollen and seed over space and time. Oecologia. 165(3): 651-661. https://www.jstor.org/stable/41499758

Moore, M.M.; Covington, W.W.; Fule, P.Z. 1999. Reference conditions and ecological restoration: a southwestern ponderosa pine perspective. Ecological Applications. 9(4): 1266-1277. doi:10.1890/1051-0761(1999)009[1266:RCAERA]2.0.CO;2

Moore, J.A.; Fan, Z.; Shaffi, B. 2002. Effect of root-plug incorporated controlled release fertilizer on two-year growth and survival of planted ponderosa pine seedlings. Western Journal of Applied Forestry. 17(4): 216-219. doi:10.1093/wjaf/17.4.216

Moore, M.M.; Huffman, D.W.; Fulé, P.Z.; Covington, W.W.; Crouse, J.E. 2004. Comparison of historical and contemporary forest structure and composition on permanent plots in southwestern ponderosa pine forests. Forest Science. 50(2): 162-176. doi:10.1093/forestscience/50.2.162

Moore, M.M.; Casey, C.A.; Bakker, J.D.; Springer, J.D.; Fulé, P.Z.; Covington, W.W.; Laughlin, D.C. 2006. Herbaceous vegetation responses (1992-2004) to restoration treatments in a ponderosa pine forest. Rangeland Ecology and Management. 59(2): 135-144. doi:10.2111/05-051R2.1

Morehouse, K.; Johns, T.; Kaye, J.; Kaye, M. 2008. Carbon and nitrogen cycling immediately following bark beetle outbreaks in southwestern ponderosa pine forests. Forest Ecology and

Management. 255(7): 2698-2708. doi:10.1016/j.foreco.2008.01.050

Morgan, P.; Aplet, G.H.; Haufler, J.B.; Humphries, H.C.; Moore, M.M.; Wilson, W.D. 1994. Historical range of variability: a useful tool for evaluating ecosystem change. Journal of Sustainable Forestry. 2: 87-111. doi:10.1300/J091v02n01_04

Morgan, P.; Hardy, C.C.; Swetnam, T.W.; Rollins, M.G.; Long, D.G. 2001. Mapping fire regimes across time and space: understanding coarse and fine-scale fire patterns. International Journal of Wildland Fire. 10(4): 329-342. doi:10.1071/WF01032

Morgan, T.A.; Fiedler, C.E.; Woodall, C. 2002. Characteristics of dry site old-growth ponderosa pine in the Bull Mountains of Montana, USA. Natural Areas Journal. 22(1): 11-19. http://www.naturalareas.org/docs/v22_1_02_pp011_019.pdf

Moritz, M.A.; Stephens, S.L. 2008. Fire and sustainability: considerations for California's altered future climate. Climatic Change. 87(1): 265-271. doi:10.1007/s10584-007-9361-1

Morris, W.G. 1934. Lightning storms and fires on the national forests of Oregon and Washington. Unnum. Rep. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 27 p.

Morris, W.G.; Mowat, E.L. 1958. Some effects of thinning a ponderosa pine thicket with a prescribed fire. Journal of Forestry. 56(3): 203-209. doi:10.1093/jof/63.2.92

Mosgrove, J.L. 1980. The Malheur National Forest: an ethnographic history. John Day, OR: USDA Forest Service, Pacific Northwest Region, Malheur National Forest. 253 p. The_Malheur_National_Forest

Mowat, E.L. 1940. Damage by logging and slash disposal in Idaho ponderosa pine. Journal of Forestry. 38(3): 247-255. doi:10.1093/jof/38.3.247

Mowat, E.L. 1953. Thinning ponderosa pine in the Pacific Northwest: a summary of present information. Res. Pap. No. 5. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 24 p. https://www.fs.usda.gov/treesearch/pubs/26024

Mowat, E.L. 1954. Effect of thinning and pruning on growth of young ponderosa pine. Northwest Science. 28(1): 18-25.

Mowat, E.L. 1961a. Effect of a transpiration retardant on survival of planted ponderosa pine. Res. Note No. 203. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 4 p. https://www.fs.usda.gov/treesearch/pubs/25859

Mowat, E.L. 1961b. Growth after partial cutting of ponderosa pine on permanent sample plots in eastern Oregon. Res. Paper 44. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 23 p. https://www.fs.usda.gov/treesearch/pubs/26064

Munger, T.T. 1912. The future yield of yellow pine stands in Oregon. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 33 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015579.pdf

Munger, T.T. 1914. Damage by light surface fires in western yellow-pine forests; Wallowa and Whitman National Forests. Proceedings of the Society of American Foresters. 9(2): 235-238. Proceedings_of_the_Society_of_American_Foresters

Munger, T.T. 1917. Western yellow pine in Oregon. Bull. No. 418. Washington, DC: U.S. Department of Agriculture. 48 p. http://organicroots.nal.usda.gov/download/CAT87211707/PDF

Munger, T.T.; Brandstrom, A.J.F.; Kolbe, E.L. 1936. Maturity selection system applied to ponderosa pine. West Coast Lumberman. 63(11): 33, 44.

Munger, T.T.; Briegleb, P.A. 1942. Recent developments in pine silviculture. Northwest Science.

16: 40-45.

Muñoz-Erickson, T.A.; Aguilar-González, B.; Sisk, T.D. 2007. Linking ecosystem health indicators and collaborative management: A systematic framework to evaluate ecological and social outcomes. Ecology and Society. 12(2): 6 (19 p). doi:10.5751/ES-02092-120206

Munson, S.M.; Yackulic, E.O.; Bair, L.S.; Copeland, S.M.; Gunnell, K.L. 2020. The biggest bang for the buck: cost-effective vegetation treatment outcomes across drylands of the western United States. Ecological Applications. 30(7): e02151 (14 p). doi:10.1002/eap.2151

Murphy, A. 1994. Graced by pines: The ponderosa pine in the American west. Missoula, MT: Mountain Press Publishing Company. 119 p. isbn:0-87842-307-9

Murphy, A.; Abrams, J.; Daniel, T.; Yazzie, V. 2007. Living among frequent-fire forests: human history and cultural perspectives. Ecology and Society. 12(2): art17 (14 p). http://www.ecologyandsociety.org/vol12/iss2/art17/

Muscolo, A.; Bagnato, S.; Sidari, M.; Mercurio, R. 2014. A review of the roles of forest canopy gaps. Journal of Forestry Research. 25(4): 725-736. doi:10.1007/s11676-014-0521-7

Mutch, R.W. 1994. Fighting fire with prescribed fire: a return to ecosystem health. Journal of Forestry. 92(11): 31-33. doi:10.1093/jof/92.11.31

Mutch, R.W.; Arno, S.F.; Brown, J.K.; Carlson, C.E.; Ottmar, R.D.; Peterson, J.L. 1993. Forest health in the Blue Mountains: a management strategy for fire-adapted ecosystems. Gen. Tech. Rep. PNW-GTR-310. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 14 p. http://www.treesearch.fs.fed.us/pubs/9056

Myers, C.A. 1967. Growing stock levels in even-aged ponderosa pine. Res. Paper RM-33. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experimental Station. 8 p. http://www.treesearch.fs.fed.us/pubs/34763

Myers, C.A. 1974. Multipurpose silviculture in ponderosa pine stands of the montane zone of central Colorado. Res. Pap. RM-132. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p. https://www.fs.fed.us/rm/pubs_exp_forests/manitou/rmrs_1974_myers_c001.pdf

Myers, C.A.; Van Deusen, J.L. 1961. Growth of immature stands of ponderosa pine in the Black Hills. Station Paper No. 61. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 14 p. https://archive.org/download/growthofimmature61myer/growthofimmature61myer.pdf

Mylek, M.R.; Schirmer, J. 2020. Understanding acceptability of fuel management to reduce wildfire risk: Informing communication through understanding complexity of thinking. Forest Policy and Economics. 113: 102120 (10 p). doi:10.1016/j.forpol.2020.102120

Naficy, C.; Sala, A.; Keeling, E.G.; Graham, J.; DeLuca, T.H. 2010. Interactive effects of historical logging and fire exclusion on ponderosa pine forest structure in the northern Rockies. Ecological Applications. 20(7): 1851-1864. doi:10.1890/09-0217.1

Nagel, L.M.; O'Hara, K.L. 2001. The influence of stand structure on ecophysiological leaf characteristics of *Pinus ponderosa* in western Montana. Canadian Journal of Forest Research. 31(12): 2173-2182. doi:10.1139/x01-156

Nagel, L.; O'Hara, K. 2002. Diurnal fluctuations of gas exchange and water potential in different stand structures of *Pinus ponderosa*. Trees. 16(4-5): 281-290. doi:10.1007/s00468-002-0176-4

Namkoong, G.; Conkle, M.T. 1976. Time trends in genetic control of height growth in ponderosa pine. Forest Science. 22(1): 2-12. doi:10.1093/forestscience/22.1.2

National Research Council. 2002. Riparian areas: Functions and strategies for management. Washington, DC: National Academies Press. 448 p. isbn:978-0-309-16977-6

National Research Council. 2011. Climate stabilization targets: Emissions, concentrations, and impacts over decades to millennia. Washington, DC: National Academies Press. 286 p. isbn:9780309151764

Naumburg, E.; DeWald, L.E. 1999. Relationships between *Pinus ponderosa* forest structure, light characteristics, and understory graminoid species presence and abundance. Forest Ecology and Management. 124(2-3): 205-215. doi:10.1016/S0378-1127(99)00067-5

Naumburg, E.; DeWald, L.E.; Kolb, T.E. 2001. Shade responses of five grasses native to southwestern U.S. Pinus ponderosa forests. Canadian Journal of Botany. 79: 1001-1009. doi:10.1139/b01-080

Neary, D.G.; Klopatek, C.C.; DeBano, L.F.; Ffolliott, P.F. 1999. Fire effects on belowground sustainability: a review and synthesis. Forest Ecology and Management. 122(1-2): 51-71. doi:10.1016/S0378-1127(99)00032-8

Nebeker, T.E.; Schmitz, R.F.; Tisdale, R.A.; Hobson, K.R. 1995. Chemical and nutritional status of dwarf mistletoe, Armillaria root rot, and Comandra blister rust infected trees which may influence tree susceptibility to bark beetle attack. Canadian Journal of Botany. 73(3): 360-369. doi:10.1139/b95-037

Neff, P. 1928. The inferior-species problem in the northern Rocky Mountains. Journal of Forestry. 26(5): 591-599. doi:10.1093/jof/26.5.591

Negron, J.F.; Popp, J.B. 2004. Probability of ponderosa pine infestation by mountain pine beetle in the Colorado Front Range. Forest Ecology and Management. 191(1-3): 17-27. doi:10.1016/j.foreco.2003.10.026

Negrón, J.F.; Shepperd, W.D.; Mata, S.A.; Popp, J.B.; Asherin, L.A.; Schoettle, A.W.; Schmid, J.M.; Leatherman, D.A. 2001. Solar treatments for reducing survival of mountain pine beetle in infested ponderosa and lodgepole pine logs. Res. Paper RMRS-RP-30. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 11 p. https://www.fs.usda.gov/treesearch/pubs/4624

Negron, J.F.; Allen, K.; Cook, B.; Withrow Jr., J.R. 2008. Susceptibility of ponderosa pine, *Pinus ponderosa* (Dougl. ex Laws.), to mountain pine beetle, *Dendroctonus ponderosae* Hopkins, attack in uneven-aged stands in the Black Hills of South Dakota and Wyoming USA. Forest Ecology and Management. 254(2): 327-334. doi:10.1016/j.foreco.2007.08.018

Negrón, J.F.; McMillin, J.D.; Anhold, J.A.; Coulson, D. 2009. Bark beetle-caused mortality in a drought-affected ponderosa pine landscape in Arizona, USA. Forest Ecology and Management. 257(4): 1353-1362. doi:10.1016/j.foreco.2008.12.002

Negrón, J.F.; Allen, K.K.; Ambourn, A.; Cook, B.; Marchand, K. 2017. Large-scale thinnings, ponderosa pine, and mountain pine beetle in the Black Hills, USA. Forest Science. 63(5): 529-536. doi:10.5849/FS-2016-061

Nelson, C.R.; Halpern, C.B.; Agee, J.K. 2008. Thinning and burning result in low-level invasion by nonnative plants but neutral effects on natives. Ecological Applications. 18(3): 762-770. doi:10.1890/07-0474.1

Newland, J.A.; DeLuca, T.H. 2000. Influence of fire on native nitrogen-fixing plants and soil nitrogen status in ponderosa pine – Douglas-fir forests in western Montana. Canadian Journal of Forest Research. 30(2): 274-282. doi:10.1139/cjfr-30-2-274

Newman, R.F.; Parminter, J.; Wallace, B.M. 2012. Understorey vegetation response following restoration of ingrown ponderosa pine and Douglas-fir stands in the East Kootenay region. Technical Rep. 071. Victoria, BC: Province of British Columbia. 39 p. http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr071.htm

Newton, A.C. 2007. Forest ecology and conservation: a handbook of techniques. Oxford, UK: Oxford University Press. 454 p. isbn:978-0-19-856744-8

Nigro, K.; Molinari, N. 2019. Status and trends of fire activity in southern California yellow pine and mixed conifer forests. Forest Ecology and Management. 441: 20-31. doi:10.1016/j.foreco.2019.01.020

Nissley, S.D.; Zasoski, R.J.; Martin, R.E. 1980. Nutrient changes after prescribed surface burning of Oregon ponderosa pine stands. In: Martin, R.E.; Edmonds, R.L.; Faulkner, D.A.; Harrington, J.B.; Fuquay, D.M.; Stocks, B.J.; Barr, S., eds. Proceedings; sixth conference on fire and forest meteorology. Washington, DC: Society of American Foresters: 214-219.

Nolan, R.H.; Drew, D.M.; O'Grady, A.P.; Pinkard, E.A.; Paul, K.; Roxburgh, S.H.; Mitchell, P.J.; Bruce, J.; Battaglia, M.; Ramp, D. 2018. Safeguarding reforestation efforts against changes in climate and disturbance regimes. Forest Ecology and Management. 424: 458-467. doi:10.1016/j.foreco.2018.05.025

Noonan-Wright, E.; Hood, S.M.; Cluck, D.R. 2010. Does raking basal duff affect tree growth rates or mortality? Western Journal of Applied Forestry. 25(4): 199-202. doi:10.1093/wjaf/25.4.199

North, M. 2012. Managing Sierra Nevada forests. Gen. Tech. Rep. PSW-GTR-237. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 184 p. http://www.treesearch.fs.fed.us/pubs/40254

North, M.P.; Hurteau, M.D. 2011. High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest. Forest Ecology and Management. 261(6): 1115-1120. doi:10.1016/j.foreco.2010.12.039

North, M.; Hurteau, M.; Fiegener, R.; Barbour, M. 2005a. Influence of fire and El Niño on tree recruitment varies by species in Sierran mixed conifer. Forest Science. 51(3): 187-197. doi:10.1093/forestscience/51.3.187

North, M.; Oakley, B.; Fiegener, R.; Gray, A.; Barbour, M. 2005b. Influence of light and soil moisture on Sierran mixed-conifer understory communities. Plant Ecology. 177(1): 13-24. doi:10.1007/s11258-005-2270-3

North, M.; Innes, J.; Zald, H. 2007. Comparison of thinning and prescribed fire restoration treatments to Sierran mixed-conifer historic conditions. Canadian Journal of Forest Research. 37(2): 331-342. doi:10.1139/X06-236

North, M.; Stine, P.; O'Hara, K.; Zielinski, W.; Stephens, S. 2009a. An ecosystem management strategy for Sierran mixed-conifer forests. Gen. Tech. Rep. PSW-GTR-220. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 49 p. http://www.treesearch.fs.fed.us/pubs/32916

North, M.P.; Van de Water, K.M.; Stephens, S.L.; Collins, B.M. 2009b. Climate, rain shadow, and human-use influences on fire regimes in the eastern Sierra Nevada, California, USA. Fire Ecology. 5(3): 20-34. doi:10.4996/fireecology.0503020

North, M.; Hurteau, M.; Innes, J. 2009c. Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions. Ecological Applications. 19(6): 1385-1396. doi:10.1890/08-1173.1

North, M.; Collins, B.M.; Stephens, S. 2012. Using fire to increase the scale, benefits, and future maintenance of fuels treatments. Journal of Forestry. 110(7): 392-401. doi:10.5849/jof.12-021

North, M.P.; Stevens, J.T.; Greene, D.F.; Coppoletta, M.; Knapp, E.E.; Latimer, A.M.; Restaino, C.M.; Tompkins, R.E.; Welch, K.R.; York, R.A.; Young, D.J.N.; Axelson, J.N.; Buckley, T.N.; Estes, B.L.; Hager, R.N.; Long, J.W.; Meyer, M.D.; Ostoja, S.M.; Safford, H.D.; Shive, K.L.; Tubbesing, C.L.; Vice, H.; Walsh, D.; Werner, C.M.; Wyrsch, P. 2019. Tamm Review: Reforestation for resilience in dry western U.S. forests. Forest Ecology and Management. 432: 209-224. doi:10.1016/j.foreco.2018.09.007

Noss, R.F. 1983. A regional landscape approach to maintain diversity. BioScience. 33(11): 700-706. doi:10.2307/1309350

Noss, R.F.; LaRoe, E.T., III; Scott, J.M. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Rep. 28. Washington, DC: U.S. Depart. of the Interior, National Biological Service. 58 p.

Noss, R.F.; Beier, P.; Covington, W.W.; Grumbine, R.E.; Lindenmayer, D.B.; Prather, J.W.; Schmiegelow, F.; Sisk, T.D.; Vosick, D.J. 2006. Recommendations for integrating restoration ecology and conservation biology in ponderosa pine forests of the southwestern United States. Restoration Ecology. 14(1): 4-10. doi:10.1111/j.1526-100X.2006.00099.x

Noste, N.V.; Bushey, C.L. 1987. Fire response of shrubs of dry forest habitat types in Montana and Idaho. Gen. Tech. Rep. INT-239. Ogden, UT: USDA Forest Service, Intermountain Research Station. 22 p. https://www.archive.org/download/CAT88892469/CAT88892469.pdf

Obedzinski, R.A.; Schmid, J.M.; Mata, S.A.; Olsen, W.K.; Kessler, R.R. 1999. Growth of ponderosa pine stands in relation to mountain pine beetle susceptibility. Gen. Tech. Rep. RMRS-GTR-28. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 13 p. http://www.treesearch.fs.fed.us/pubs/31983

Oberle, M. 1969. Forest fires: suppression policy has its ecological drawbacks. Science. 165(3893): 568-571. doi:10.1126/science.165.3893.568

O'Connor, C.D.; Falk, D.A.; Lynch, A.M.; Swetnam, T.W. 2014. Fire severity, size, and climate associations diverge from historical precedent along an ecological gradient in the Pinaleño Mountains, Arizona, USA. Forest Ecology and Management. 329: 264-278. doi:10.1016/j.foreco.2014.06.032

Odion, D.C.; Hanson, C.T.; Arsenault, A.; Baker, W.L.; DellaSala, D.A.; Hutto, R.L.; Klenner, W.; Moritz, M.A.; Sherriff, R.L.; Veblen, T.T.; Williams, M.A. 2014. Examining historical and current mixed-severity fire regimes in ponderosa pine and mixed-conifer forests of western North America. PLoS ONE. 9(2): e87852. doi:10.1371/journal.pone.0087852

O'Donnell, F.C.; Flatley, W.T.; Springer, A.E.; Fulé, P.Z. 2018. Forest restoration as a strategy to mitigate climate impacts on wildfire, vegetation, and water in semiarid forests. Ecological Applications. 28(6): 1459-1472. doi:10.1002/eap.1746

Oester, P.T.; Emmingham, W.; Larson, P.; Clements, S. 1995. Performance of ponderosa pine seedlings under four herbicide regimes in northeast Oregon. New Forests. 10(2): 123-131. doi:10.1007/BF00033402

O'Hara, K.L. 1995. Early height development and species stratification across five climax series in the eastern Washington Cascade Range. New Forests. 9(1): 53-60. doi:10.1007/BF00028925

O'Hara, K.L. 1996. Dynamics and stocking-level relationships of multi-aged ponderosa pine stands. Forest Science. 42(Supplement 2): 1-34. doi:10.1093/forestscience/42.s2.a0001

O'Hara, K.L. 2014. Multiaged silviculture: Managing for complex forest stand structures. First ed. New York: Oxford University Press. 213 p. isbn:9780198703068 doi:10.1093/acprof:oso/9780198703068.001.0001

O'Hara, K.L.; Buckland, P.A. 1996. Prediction of pruning wound occlusion and defect core size in ponderosa pine. Western Journal of Applied Forestry. 11(2): 40-43. doi:10.1093/wjaf/11.2.40

O'Hara, K.L.; Nagel, L.M. 2006. A functional comparison of productivity in even-aged and multi-aged stands: a synthesis for *Pinus ponderosa*. Forest Science. 52(3): 290-303. doi:10.1093/forestscience/52.3.290

O'Hara, K.L.; Valappil, N.I. 1995. Sapwood–leaf area prediction equations for multi-aged ponderosa pine stands in western Montana and central Oregon. Canadian Journal of Forest Research. 25(9): 1553-1557. doi:10.1139/x95-169

O'Hara, K.L.; Latham, P.A.; Hessburg, P.; Smith, B.G. 1996. A structural classification for inland northwest forest vegetation. Western Journal of Applied Forestry. 11(3): 97-102. doi:10.1093/wjaf/11.3.97

O'Hara, K.L.; Valappil, N.I.; Nagel, L.M. 2003. Stocking control procedures for multiaged ponderosa pine stands in the inland Northwest. Western Journal of Applied Forestry. 18(1): 5-14. doi:10.1093/wjaf/18.1.5

O'Hara, K.L.; Youngblood, A.; Waring, K.M. 2010. Maturity selection versus improvement selection: lessons from a mid-20th century controversy in the silviculture of ponderosa pine. Journal of Forestry. 108(8): 397-407. doi:10.1093/jof/108.8.397

O'Laughlin, J.; MacCracken, J.G.; Adams, D.L.; Bunting, S.C.; Blatner, K.A.; Keegan, C.E., III. 1993. Forest health conditions in Idaho. Rep. No. 11. Moscow, ID: University of Idaho, Idaho Forest, Wildlife and Range Experiment Station, Idaho Forest, Wildlife and Range Policy Analysis Group. 244 p.

Oliver, W.W. 1984. Brush reduces growth of thinned ponderosa pine in northern California. Res. Paper PSW-172. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 7 p. https://www.fs.usda.gov/treesearch/pubs/28833

Oliver, W.W. 1995. Is self-thinning in ponderosa pine ruled by *Dendroctonus* bark beetles? In: Eskew, L.G., comp. Forest health through silviculture; proceedings of the 1995 National Silviculture Workshop. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 213-218. http://www.treesearch.fs.fed.us/pubs/23504

Oliver, W.W. 1997a. Can we sustain uneven-aged ponderosa stands? An interdisciplinary study in northeastern California. In: Emmingham, W.H., comp. Proceedings of the IUFRO interdisciplinary uneven-aged management symposium. [Corvallis, OR]: [Oregon State University]: 610-618.

Oliver, W.W. 1997b. Twenty-five-year growth and mortality of planted ponderosa pine repeatedly thinned to different stand densities in northern California. Western Journal of Applied Forestry. 12(4): 122-130. doi:10.1093/wjaf/12.4.122

Oliver, W.W.; Edminster, C.B. 1988. Growth of ponderosa pine thinned to different stocking levels in the western United States. In: Schmidt, W.C., comp. Proceedings – future forests of the mountain west: A stand culture symposium. Ogden, UT: USDA Forest Service, Intermountain Research Station: 153-159. https://www.fs.usda.gov/treesearch/pubs/48216

Oliver, C.D.; Larson, B.C. 1996. Forest stand dynamics. Update edition. New York: John Wiley &

Sons. 520 p. isbn:0-471-13833-9

Oliver, W.W.; Ryker, R.A. 1990. *Pinus ponderosa* Dougl. ex Laws.; ponderosa pine. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America; volume 1, conifers. Agric. Handb. 654. Washington, DC: USDA Forest Service: 413-424. https://www.treesearch.fs.fed.us/pubs/1547

Oliver, W.W.; Uzoh, F.C.C. 1997. Maximum stand densities for ponderosa pine and red and white fir in northern California. In: Landram, M., chair. Proceedings: 18th annual forest vegetation management conference. Redding, CA: Forest Vegetation Management Conference: 57-65. http://www.fvmc.org/PDF/FVMCProc18th(1997).pdf

Oliver, C.D.; Ferguson, D.E.; Harvey, A.E.; Malany, H.S.; Mandzak, J.M.; Mutch, R.W. 1994a. Managing ecosystems for forest health: an approach and the effects on uses and values. Journal of Sustainable Forestry. 2(1/2): 113-133. doi:10.1300/J091v02n01_05

Oliver, C.D.; Harrington, C.; Bickford, M.; Gara, R.; Knapp, W.; Lightner, G.; Hicks, L. 1994b. Maintaining and creating old growth structural features in previously disturbed stands typical of the eastern Washington Cascades. Journal of Sustainable Forestry. 2(3-4): 353-387. doi:10.1300/J091v02n03_09

Oliver, C.D.; Irwin, L.L.; Knapp, W.H. 1994c. Eastside forest management practices: historical overview, extent of their applications, and their effects on sustainability of ecosystems. Gen. Tech. Rep. PNW-GTR-324. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 73 p. http://www.treesearch.fs.fed.us/pubs/6294

Oliver, C.D.; Osawa, A.; Camp, A. 1997. Forest dynamics and resulting animal and plant population changes at the stand and landscape levels. Journal of Sustainable Forestry. 6(3):281-312. doi:10.1300/J091v06n03_05

Olmsted, F.E. 1911. Fire and the forest—the theory of "light burning". Sierra Club Bulletin. 8(1): 43-47 (plus 2 unnumbered plate pages). https://archive.org/download/sierraclubbu819111912sier/sierraclubbu819111912sier.pdf

Olsen, W.K.; Schmid, J.M.; Mata, S.A. 1996. Stand characteristics associated with mountain pine beetle infestations in ponderosa pine. Forest Science. 42(3): 310-327. doi:10.1093/forestscience/42.3.310

Olsen, C.S.; Mallon, A.L.; Shindler, B.A. 2012. Public acceptance of disturbance-based forest management: Factors influencing support. ISRN Forestry. 2012: 594067 (11 p). doi:10.5402/2012/594067

Olsen, C.S.; Kline, J.D.; Ager, A.A.; Olsen, K.A.; Short, K.C. 2017. Examining the influence of biophysical conditions on wildland-urban interface homeowners' wildfire risk mitigation activities in fire-prone landscapes. Ecology and Society. 22(1): 21 (20 p). doi:10.5751/ES-09054-220121

Olson, J.S. 1963. Energy storage and the balance of producers and decomposers in ecological systems. Ecology. 44(2): 322-331. doi:10.2307/1932179

Olson, R.J. 1969. Applying Liebig's law of the minimum to the management of ponderosa pine. Journal of Forestry. 67(10): 751-753. doi:10.1093/jof/67.10.751

Olson, D.L. 2000. Fire in riparian zones: a comparison of historical fire occurrence in riparian and upslope forests in the Blue Mountains and southern Cascades of Oregon. M.S. thesis. Seattle, WA: University of Washington. 274 p. https://www.fs.fed.us/rm/pubs/rmrs_gtr292/2000_olsen.pdf

Olson, D.L.; Agee, J.K. 2005. Historical fires in Douglas-fir dominated riparian forests of the southern Cascades, Oregon. Fire Ecology. 1(1): 50-74. doi:10.4996/fireecology.0101050

Olsson, P.; Folke, C.; Berkes, F. 2004. Adaptive comanagement for building resilience in social-ecological systems. Environmental Management. 34(1): 75-90. doi:10.1007/s00267-003-0101-7

Omi, P.N.; Joyce, L.A. 2003. Fire, fuel treatments, and ecological restoration: conference proceedings. Proceedings RMRS-P-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 475 p. http://www.treesearch.fs.fed.us/pubs/5578

Omi, P.N.; Kalabokidis, K.D. 1991. Fire damage on extensively vs. intensively managed forest stands within the North Fork Fire, 1988. Northwest Science. 65(4): 149-157. https://research.wsulibs.wsu.edu:8443/xmlui/handle/2376/1639

Omi, S.K.; Rose, R.; Sabin, T.E. 1991. Effectiveness of freezer storage in fulfilling the chilling requirement of fall-lifted ponderosa pine seedlings. New Forests. 5(4): 307-326. doi:10.1007/BF00118859

Omi, S.K.; Rose, R.; Sabin, T.E. 1994. Fall lifting and long-term freezer storage of ponderosa pine seedlings: Effects on starch, root growth, and field performance. Canadian Journal of Forest Research. 24(3): 624-637. doi:10.1139/x94-082

Ontl, T.A.; Janowiak, M.K.; Swanston, C.W.; Daley, J.; Handler, S.; Cornett, M.; Hagenbuch, S.; Handrick, C.; Mccarthy, L.; Patch, N. 2020. Forest management for carbon sequestration and climate adaptation. Journal of Forestry. 118(1): 86-101. doi:10.1093/jofore/fvz062

Oregon Forest Resources Institute. 2002. Fire in Oregon's forests: assessing the risks, effects and treatment options. Portland, OR: Oregon Forest Resources Institute. 16 p.

Oren, R.; Waring, R.H.; Stafford, S.G.; Barrett, J.W. 1987. Twenty-four years of ponderosa pine growth in relation to canopy leaf area and understory competition. Forest Science. 33(2): 538-547. doi:10.1093/forestscience/33.2.538

Orr, H.K. 1972. Throughfall and stemflow relationships in second-growth ponderosa pine in the Black Hills. Res. Note RM-210. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p. https://archive.org/download/CAT72351665/CAT72351665.pdf

Oswald, B.P.; Wellner, K.; Boyce, R.; Neuenschwander, L.F. 1999. Germination and initial growth of four coniferous species on varied duff depths in northern Idaho. Journal of Sustainable Forestry. 8(1): 11-21. doi:10.1300/J091v08n01_02

Oswalt, S.N.; Smith, W.B.; Miles, P.D.; Pugh, S.A. 2019. Forest resources of the United States, 2017: A technical document supporting the Forest Service 2020 RPA assessment. Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 223 p. https://www.fs.usda.gov/treesearch/pubs/57903

Ouzts, J.; Kolb, T.; Huffman, D.; Sánchez Meador, A. 2015. Post-fire ponderosa pine regeneration with and without planting in Arizona and New Mexico. Forest Ecology and Management. 354: 281-290. doi:10.1016/j.foreco.2015.06.001

Owen, D.R.; Lindahl, K.Q., Jr.; Wood, D.L.; Parmeter, J.R., Jr. 1987. Pathogenicity of fungi isolated from *Dendroctonus valens, D. brevicomis*, and *D. ponderosae* to ponderosa pine seedlings. Phytopathology. 77(4): 631-636. doi: 10.1094/Phyto-77-631

Owen, S.M.; Sieg, C.H.; Sánchez Meador, A.J.; Fulé, P.Z.; Iniguez, J.M.; Baggett, L.S.; Fornwalt, P.J.; Battaglia, M.A. 2017. Spatial patterns of ponderosa pine regeneration in high-severity burn patches. Forest Ecology and Management. 405: 134-149. doi:10.1016/j.foreco.2017.09.005

Owston, P.W.; Seidel, K.W. 1978. Container and root treatments affect growth and root form of planted ponderosa pine. Canadian Journal of Forest Research. 8(2): 232-236. doi:10.1139/x78-036

Panek, J.A.; Goldstein, A.H. 2001. Response of stomatal conductance to drought in ponderosa pine: implications for carbon and ozone uptake. Tree Physiology. 21(5): 337-344. doi:10.1093/treephys/21.5.337

Parfit, M. 1996. The essential element of fire. National Geographic. 190(3): 116-139.

Parker, J. 1955. Annual trends in cold hardiness of ponderosa pine and grand fir. Ecology. 36(3): 377-380. doi:10.2307/1929571

Parker, T.J.; Clancy, K.M.; Mathiasen, R.L. 2006. Interactions among fire, insects and pathogens in coniferous forests of the interior western United States and Canada. Agricultural and Forest Entomology. 8(3): 167-189. doi:10.1111/j.1461-9563.2006.00305.x

Parker, R.T.; Maguire, D.A.; Marshall, D.D.; Cochran, P. 2007. Ponderosa pine growth response to soil strength in the volcanic ash soils of central Oregon. Western Journal of Applied Forestry. 22(2): 134-141. doi:10.1093/wjaf/22.2.134

Parks, C.G.; Bednar, L.; Tiedemann, A.R. 1998. Browsing ungulates – an important consideration in dieback and mortality of Pacific yew *(Taxus brevifolia)* in a northeastern Oregon stand. Northwest Science. 72(3): 190-197. http://hdl.handle.net/2376/1215

Parks, C.G.; Conklin, D.A.; Bednar, L.; Maffei, H. 1999. Woodpecker use and fall rates of snags created by killing ponderosa pine infected with dwarf mistletoe. Res. Paper PNW-RP-515. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 11 p. https://www.fs.usda.gov/treesearch/pubs/2911

Parks, S.A.; Miller, C.; Parisien, M.-A.; Holsinger, L.M.; Dobrowski, S.Z.; Abatzoglou, J. 2015. Wildland fire deficit and surplus in the western United States, 1984-2012. Ecosphere. 6(12): 275 (13 p). doi:10.1890/es15-00294.1

Parks, S.A.; Holsinger, L.M.; Miller, C.; Parisien, M.-A. 2018a. Analog-based fire regime and vegetation shifts in mountainous regions of the western US. Ecography. 41(6): 910-921. doi:10.1111/ecog.03378

Parks, S.A.; Dobrowski, S.Z.; Panunto, M.H. 2018b. What drives low-severity fire in the southwestern USA? Forests. 9(4): 165 (14 p). doi:10.3390/f9040165

Parsons, D.J.; DeBenedetti, S.H. 1979. Impact of fire suppression on a mixed-conifer forest. Forest Ecology and Management. 2: 21-33. doi:10.1016/0378-1127(79)90034-3

Passovoy, M.D.; Fulé, P.Z. 2006. Snag and woody debris dynamics following severe wildfires in northern Arizona ponderosa pine forests. Forest Ecology and Management. 223(1-3): 237-246. doi:10.1016/j.foreco.2005.11.016

Patterson, J.E. 1929. The pandora moth, a periodic pest of western pine forests. Tech. Bull. No. 137. Washington, DC: U.S. Department of Agriculture. 20 p. https://naldc.nal.usda.gov/download/CAT86200131/PDF

Patton, D.R. 1977. Managing southwestern ponderosa pine for the Abert squirrel. Journal of Forestry. 75(5): 264-267. doi: 10.1093/jof/75.5.264

Paul, E.A., ed. 2007. Soil microbiology, ecology, and biochemistry. Burlington, MA: Academic Press. 532 p. isbn:978-0-12-546807-7

Pausas, J.G.; Keeley, J.E. 2009. A burning story: the role of fire in the history of life. BioScience. 59(7): 593-601. doi:10.1525/bio.2009.59.7.10

Pawlikowski, N.C.; Coppoletta, M.; Knapp, E.; Taylor, A.H. 2019. Spatial dynamics of tree group and gap structure in an old-growth ponderosa pine-California black oak forest burned by repeated wildfires. Forest Ecology and Management. 434: 289-302. doi:10.1016/j.foreco.2018.12.016

Pearson, G.A. 1910. Reproduction of western yellow pine in the Southwest. Circular 174. Washington, DC: USDA Forest Service. 16 p.

Pearson, G.A. 1912. The influence of age and condition of the tree upon seed production in western yellow pine. Circular 196. Washington, DC: USDA Forest Service. 11 p. Circular

Pearson, G.A. 1913. A meteorological study of parks and timbered areas in the western yellow pine forests of Arizona and New Mexico. Monthly Weather Review. 41(10): 1615-1629. https://www.fs.usda.gov/treesearch/pubs/29548

Pearson, G.A. 1918. The relation between spring precipitation and height growth of western yellow-pine saplings in Arizona. Journal of Forestry. 16(6): 677-689. doi:10.1093/jof/16.6.677

Pearson, G.A. 1923. Natural reproduction of western yellow pine in the southwest. Bull. No. 1105. Washington, DC: U.S. Department of Agriculture. 143 p. https://archive.org/download/naturalreproduct1105pear/naturalreproduct1105pear.pdf

Pearson, G.A. 1930. Light and moisture in forestry. Ecology. 11(1): 145-160. doi:10.2307/1930787

Pearson, G.A. 1931. Forest types in the southwest as determined by climate and soil. Tech. Bull. No. 247. Washington, DC: U.S. Department of Agriculture. 144 p. https://naldc.nal.usda.gov/download/CAT86200241/PDF

Pearson, G.A. 1936. Some observations on the reaction of pine seedlings to shade. Ecology. 17(2): 270-276. doi:10.2307/1931467

Pearson, G.A. 1939. Mortality in cutover stands of ponderosa pine. Journal of Forestry. 37(5): 383-387. doi:10.1093/jof/37.5.383

Pearson, G.A. 1942a. Herbaceous vegetation: a factor in natural regeneration of ponderosa pine in the southwest. Ecological Monographs. 12(3): 315-338. doi:10.2307/1943545

Pearson, G.A. 1942b. Improvement selection cutting in ponderosa pine. Journal of Forestry. 40(10): 753-766. doi:10.1093/jof/40.10.753

Pearson, G.A.; Marsh, R.E. 1935. Timber growing and logging practice in the Southwest and in the Black Hills region. Tech. Bull. No. 480. Washington, DC: U.S. Department of Agriculture. 80 p. https://naldc.nal.usda.gov/download/CAT86200474/PDF

Pearson, G.A.; McIntyre, A.C. 1935. Slash disposal in ponderosa pine forests of the Southwest. Circular No. 357. Washington, DC: U.S. Department of Agriculture. 29 p. Slash_Disposal_in_Ponderosa_Pine_Forests

Pedersen, B.S. 1998. Modeling tree mortality in response to short- and long-term environmental stresses. Ecological Modelling. 105(2-3): 347-351. doi:10.1016/S0304-3800(97)00162-2

Peet, R.K.; Christensen, N.L. 1987. Competition and tree death. BioScience. 37(8): 586-595. doi:10.2307/1310669

Pehl, C.E.; Red, J.T.; Shelnutt, H.E. 1986. Controlled burning and land treatment influences on chemical properties of a forest soil. Forest Ecology and Management. 17(2-3): 119-128. doi:10.1016/0378-1127(86)90104-0

Peipoch, M.; Brauns, M.; Hauer, F.R.; Weitere, M.; Valett, H.M. 2015. Ecological simplification: Human influences on riverscape complexity. BioScience. 65(11): 1057-1065.

doi:10.1093/biosci/biv120

Pelren, E.C.; Crawford, J.A. 1999. Blue grouse nesting parameters and habitat associations in northeastern Oregon. Great Basin Naturalist. 59(4): 368-373. https://www.jstor.org/stable/41713138

Perera, A.H.; Buse, L.J.; Weber, M.G., eds. 2004. Emulating natural forest landscape disturbances: concepts and applications. New York, NY: Columbia University Press. 315 p. isbn:0-231-12916-5

Perrakis, D.D.B.; Agee, J.K. 2006. Seasonal fire effects on mixed-conifer forest structure and ponderosa pine resin properties. Canadian Journal of Forest Research. 36(1): 238-254. doi:10.1139/x05-212

Perrakis, D.D.B.; Agee, J.K.; Eglitis, A. 2011. Effects of prescribed burning on mortality and resin defenses in old growth ponderosa pine (Crater Lake, Oregon): four years of post-fire monitoring. Natural Areas Journal. 31(1): 14-25. doi:10.3375/043.031.0103

Perry, W.J. 1999. Walt Perry, an early-day forest ranger in New Mexico and Oregon; a memoir by Walter J. Perry. Joslin, L., ed. Bend, OR: Wilderness Associates. 190 p. isbn:0-9647167-2-0

Perry, D.A.; Amaranthus, M.P. 1997. Disturbance, recovery, and stability. Chapter 3. In: Kohm, K.A.; Franklin, J.F., eds. Creating a forestry for the 21st century: The science of ecosystem management. Washington, DC: Island Press: 31-56. http://andrewsforest.oregonstate.edu/pubs/pdf/pub2333.pdf

Perry, D.A.; Jing, H.; Youngblood, A.; Oetter, D.R. 2004. Forest structure and fire susceptibility in volcanic landscapes of the eastern high Cascades, Oregon. Conservation Biology. 18(4): 913-926. doi:10.1111/j.1523-1739.2004.00530.x

Perry, D.A.; Oren, R.; Hart, S.C. 2008. Forest ecosystems. 2nd edition. Baltimore, MD: Johns Hopkins University Press. 606 p. isbn:978-0-8018-8840-3

Person, H.L. 1931. Theory in explanation of the selection of certain trees by the western pine beetle. Journal of Forestry. 29(5): 696-699. doi:10.1093/jof/29.5.696

Peters, G.; Sala, A. 2008. Reproductive output of ponderosa pine in response to thinning and prescribed burning in western Montana. Canadian Journal of Forest Research. 38(4): 844-850. doi:10.1139/X07-203

Petersen, T.D. 1988. Effects of interference from *Calamagrostis rubescens* on size distributions in stands of *Pinus ponderosa*. Journal of Applied Ecology. 25(1): 265-272. doi:10.2307/2403624

Peterson, J.D. 1992. Grey ghosts in the Blue Mountains. Evergreen. (January/February): 3-8.

Peterson, G.D. 2002. Contagious disturbance, ecological memory, and the emergence of landscape pattern. Ecosystems. 5(4): 329-338. doi:10.1007/s10021-001-0077-1

Peterson, D.W.; Harrod, R.L. 2010. Fuel succession, post-fire logging, and future fire behavior: Addressing the "reburn problem." Final report to the Joint Fire Sciences Program for project number 06-3-4-16. Wenatchee, WA: USDF Forest Service, Pacific Northwest Research Station, Wenatchee Forestry Sciences Laboratory.

Peterson, D.L.; Johnson, M.C. 2007. Science-based strategic planning for hazardous fuel treatment. Fire Management Today. 67(3): 13-18. https://www.fs.fed.us/fire/fmt/fmt_pdfs/FMT67-3.pdf

Peterson, D.L.; Sackett, S.S.; Robinson, L.J.; Haase, S.M. 1994. The effects of repeated prescribed burning on *Pinus ponderosa* growth. International Journal of Wildland Fire. 4(4):

239-247. doi:10.1071/WF9940239

Peterson, D.L.; Johnson, M.C.; Agee, J.K.; Jain, T.B.; McKenzie, D.; Reinhardt, E.D. 2005. Forest structure and fire hazard in dry forests of the western United States. Gen. Tech. Rep. PNW-GTR-628. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 30 p. http://www.treesearch.fs.fed.us/pubs/8572

Peterson, D.L.; Evers, L.; Gravenmier, R.A.; Eberhardt, E. 2007a. A consumer guide: Tools to manage vegetation and fuels. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 151 p. https://www.fs.usda.gov/treesearch/pubs/25953

Peterson, D.W.; Hessburg, P.F.; Salter, B.; James, K.M.; Dahlgreen, M.C.; Barnes, J.A. 2007b. Reintroducing fire in regenerated dry forests following stand-replacing wildfire. In: Powers, R.F., tech. ed. Restoring fire-adapted ecosystems: proceedings of the 2005 national silviculture workshop. Gen. Tech. Rep. PSW-GTR-203. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 79-86. https://www.fs.usda.gov/treesearch/pubs/25894

Peterson, D.L.; Halofsky, J.E.; Johnson, M.C. 2011a. Managing and adapting to changing fire regimes in a warmer climate. Chapter 10. In: McKenzie, D.; Miller, C.; Falk, D. A., eds. The Landscape Ecology of Fire. Ecological Studies 213. Springer: 249-267. isbn:978-94-007-0300-1

Peterson, D.L.; Millar, C.I.; Joyce, L.A.; Furniss, M.J.; Halofsky, J.E.; Neilson, R.P.; Morelli, T.L. 2011b. Responding to climate change in national forests: a guidebook for developing adaptation options. Gen. Tech. Rep. PNW-GTR-855. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 109 p. http://www.treesearch.fs.fed.us/pubs/39884

Peterson, D.W.; Dodson, E.K.; Harrod, R.J. 2015. Post-fire logging reduces surface woody fuels up to four decades following wildfire. Forest Ecology and Management. 338: 84-91. doi:10.1016/j.foreco.2014.11.016

Petrakis, R.E.; Villarreal, M.L.; Wu, Z.; Hetzler, R.; Middleton, B.R.; Norman, L.M. 2018. Evaluating and monitoring forest fuel treatments using remote sensing applications in Arizona, U.S.A. Forest Ecology and Management. 413: 48-61. doi:10.1016/j.foreco.2018.01.036

Petrie, M.D.; Wildeman, A.M.; Bradford, J.B.; Hubbard, R.M.; Lauenroth, W.K. 2016. A review of precipitation and temperature control on seedling emergence and establishment for ponderosa and lodgepole pine forest regeneration. Forest Ecology and Management. 361: 328-338. doi:10.1016/j.foreco.2015.11.028

Pettit, J.L.; Derose, R.J.; Long, J.N. 2018. Climatic drivers of ponderosa pine growth in central Idaho. Tree-Ring Research. 74(2): 172-184. doi:10.3959/1536-1098-74.2.172

Pfister, R.D. 1993. The need and potential for ecosystem management in forests of the inland west. In: Aplet, G.H.; Johnson, N.; Olson, J.T.; Sample, V.A., eds. Defining sustainable forestry. Washington, DC: Island Press: 217-239. isbn:1-55963-234-8

Phillips, J. 1995. The crisis in our forests. Sunset. 195(1): 87-92.

Phillips, M.A.; Croteau, R.B. 1999. Resin-based defenses in conifers. Trends in Plant Science. 4(5): 184-190. doi:10.1016/S1360-1385(99)01401-6

Phoebus, I.; Segelbacher, G.; Stenhouse, G.B. 2017. Do large carnivores use riparian zones? Ecological implications for forest management. Forest Ecology and Management. 402: 157-165. doi:10.1016/j.foreco.2017.07.037

Pickett, S.T.A.; Parker, V.T. 1994. Avoiding the old pitfalls: opportunities in a new discipline. Restoration Ecology. 2: 75-79. doi:10.1111/j.1526-100X.1994.tb00044.x

Pickford, G.D.; Reid, E.H. 1943. Competition of elk and domestic livestock for summer range forage. Journal of Wildlife Management. 7(3): 328-332. http://www.jstor.org/stable/3795540

Pierce, J.L.; Meyer, G.A.; Jull, A.J.T. 2004. Fire-induced erosion and millennial-scale climate change in northern ponderosa pine forests. Nature. 432(7013): 87-90. doi:10.1038/nature03058

Pierson, E.A.; Mack, R.N. 1990. The population biology of *Bromus tectorum* in forests: effect of disturbance, grazing, and litter on seedling establishment and reproduction. Oecologia. 84(4): 526-533. http://www.jstor.com/stable/4219460

Pierson, J.C.; Mills, L.S.; Christian, D.P. 2010. Foraging patterns of cavity-nesting birds in fire-suppressed and prescribe-burned ponderosa pine forests in Montana. Open Environmental Sciences. 4: 41-52. doi:10.2174/1876325101004010041

Pilliod, D.S.; Bull, E.L.; Hayes, J.L.; Wales, B.C. 2006. Wildlife and invertebrate response to fuel reduction treatments in dry coniferous forests of the western United States: a synthesis. Gen. Tech. Rep. RMRS-GTR-173. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 34 p. https://www.fs.usda.gov/treesearch/pubs/24469

Piñol, J.; Sala, A. 2000. Ecological implications of xylem cavitation for several Pinaceae in the Pacific Northern USA. Functional Ecology. 14(5): 538-545. doi:10.1046/j.1365-2435.2000.t01-1-00451.x

Piñol, J.; Beven, K.; Viegas, D.X. 2005. Modelling the effect of fire-exclusion and prescribed fire on wildfire size in Mediterranean ecosystems. Ecological Modelling. 183(4): 397-409. doi:10.1016/j.ecolmodel.2004.09.001

Pipas, M.J.; Witmer, G.W. 1999. Evaluation of physical barriers to protect ponderosa pine seedlings from pocket gophers. Western Journal of Applied Forestry. 14(3): 164-168. doi:10.1093/wjaf/14.3.164

Pitman, G.B.; Perry, D.A.; Emmingham, W.H. 1982. Thinning to prevent mountain pine beetles in lodgepole and ponderosa pine. Exten. Circ. 1106. Corvallis, OR: Oregon State University, Extension Service. 4 p. administrative_report_or_publications

Platt, R.V.; Veblen, T.T.; Sherriff, R.L. 2006. Are wildfire mitigation and restoration of historic forest structure compatible? A spatial modeling assessment. Annals of the Association of American Geographers. 96(3): 455-470. doi:10.1111/j.1467-8306.2006.00700.x

Pollet, J.; Omi, P.N. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. International Journal of Wildland Fire. 11(1): 1-10. doi:10.1071/WF01045

Porter, O.M. 1915. The fire problem on the Malheur National Forest. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 55 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015583.pdf

Powell, D.C. 1994. Effects of the 1980s western spruce budworm outbreak on the Malheur National Forest in northeastern Oregon. Tech. Pub. R6-FI&D-TP-12-94. Portland, OR: USDA Forest Service, Pacific Northwest Region. 176 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5358589.pdf

Powell, D.C. 1995. Annual forest monitoring and evaluation report for FY1994; file designation 1920-2-3 memorandum to Planning Staff Officer. Pendleton, OR: USDA Forest Service, Umatilla National Forest, Supervisor's Office. 18 p.

Powell, D.C. 1999a. Historical references about vegetation conditions: A bibliography with abstracts. Tech. Pub. F14-SO-TP-05-99. Pendleton, OR: USDA Forest Service, Pacific Northwest

Region, Umatilla National Forest. 310 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3798058.pdf

Powell, D.C. 1999b. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington: an implementation guide for the Umatilla National Forest. Tech. Pub. F14-SO-TP-03-99. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 300 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5405482.pdf

Powell, D.C. 2000. Potential vegetation, disturbance, plant succession, and other aspects of forest ecology. Tech. Pub. F14-SO-TP-09-00. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 88 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5358579.pdf

Powell, D.C. 2010. Estimating crown fire susceptibility for project planning. Fire Management Today. 70(3): 8-15. http://www.fs.fed.us/fire/fmt/fmt_pdfs/FMT70-3.pdf

Powell, D.C. 2012. Is elk thermal cover ecologically sustainable? White Pap. F14-SO-WP-Silv-9. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 23 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5343975.pdf

Powell, D.C. 2013a. Description of composite vegetation database. White Pap. F14-SO-WP-Silv-2. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 39 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5326218.pdf

Powell, D.C. 2013b. Stand density protocol for mid-scale assessments. White Pap. F14-SO-WP-Silv-36. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 67 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5413734.pdf

Powell, D.C. 2018. How to prepare a silvicultural prescription for uneven-aged management. White Paper F14-SO-WP-Silv-49. Pendleton, Oregon: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 105 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3794793.pdf

Powell, D.C. 2019a. Active management of moist forests in the Blue Mountains: silvicultural considerations. White Pap. F14-SO-WP-Silv-7. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 440 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3795912.pdf

Powell, D.C. 2019b. New perspectives in riparian management: Why might we want to consider active management for certain portions of riparian habitat conservation areas? White Pap. F14-SO-WP-Silv-52. Pendleton, OR: USDA Forest Service, Umatilla National Forest. 180 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3794794.pdf

Powell, D.C. 2019c. Range of variation recommendations for dry, moist, and cold forests. White Pap. F14-SO-WP-Silv-3. Pendleton, Oregon: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 79 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5326219.pdf

Powell, D.C.; Rockwell, V.A.; Townsley, J.J.; Booser, J.; Bulkin, S.P.; Martin, T.H.; Obedzinski, B.; Zensen, F. 2001. Forest density management: recent history and trends for the Pacific Northwest Region. Tech. Pub. R6-NR-TM-TP-05-01. Portland, OR: USDA Forest Service, Pacific Northwest Region. 21 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015663.pdf

Powell, D.C.; Johnson, C.G., Jr.; Crowe, E.A.; Wells, A.; Swanson, D.K. 2007. Potential vegetation hierarchy for the Blue Mountains section of northeastern Oregon, southeastern Washington, and west-central Idaho. Gen. Tech. Rep. PNW-GTR-709. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 87 p. http://www.treesearch.fs.fed.us/pubs/27598

Powers, R.F.; Jackson, G.D. 1978. Ponderosa pine response to fertilization: influence of brush removal and soil type. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 9 p. https://www.fs.usda.gov/treesearch/pubs/30601

Powers, R.F.; Oliver, W.W. 1970. Snow breakage in a pole-sized ponderosa pine plantation... more damage at high stand densities. Res. Note PSW-218. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 3 p. https://www.fs.usda.gov/treesearch/pubs/30821

Powers, R.F.; Reynolds, P.E. 1999. Ten-year responses of ponderosa pine plantations to repeated vegetation and nutrient control along an environmental gradient. Canadian Journal of Forest Research. 29(7): 1027-1038. doi:10.1139/x99-104

Powers, R.F.; Reynolds, P.E. 2000. Intensive management of ponderosa pine plantations: sustainable productivity for the 21st century. Journal of Sustainable Forestry. 10(3/4): 249-255. doi:10.1300/J091v10n03_07

Pratt, D.W.; Black, R.A.; Zamora, B.A. 1984. Buried viable seed in a ponderosa pine community. Canadian Journal of Botany. 62(1): 44-52. doi:10.1139/b84-008

Prestemon, J.P.; Abt, K.L.; Barbour, R.J. 2012. Quantifying the net economic benefits of mechanical wildfire hazard treatments on timberlands of the western United States. Forest Policy and Economics. 21: 44-53. doi:10.1016/j.forpol.2012.02.006

Prichard, S.J.; Kennedy, M.C. 2012. Fuel treatment effects on tree mortality following wildfire in dry mixed conifer forests, Washington State, USA. International Journal of Wildland Fire. 21(8): 1004-1013. doi:10.1071/WF11121

Prichard, S.J.; Kennedy, M.C. 2014. Fuel treatments and landform modify landscape patterns of burn severity in an extreme fire event. Ecological Applications. 24(3): 571-590. doi:10.1890/13-0343.1

Prichard, S.J.; Peterson, D.L.; Jacobson, K. 2010. Fuel treatments reduce the severity of wildfire effects in dry mixed conifer forest, Washington, USA. Canadian Journal of Forest Research. 40(8): 1615-1626. doi:10.1139/X10-109

Prichard, S.J.; Kennedy, M.C.; Wright, C.S.; Cronan, J.B.; Ottmar, R.D. 2017a. Predicting forest floor and woody fuel consumption from prescribed burns in southern and western pine ecosystems of the United States. Data in Brief. 15: 742-746. doi:10.1016/j.dib.2017.10.029

Prichard, S.J.; Kennedy, M.C.; Wright, C.S.; Cronan, J.B.; Ottmar, R.D. 2017b. Predicting forest floor and woody fuel consumption from prescribed burns in southern and western pine ecosystems of the United States. Forest Ecology and Management. 405: 328-338. doi:10.1016/j.foreco.2017.09.025

Prichard, S.J.; Stevens-Rumann, C.S.; Hessburg, P.F. 2017c. Tamm Review: Shifting global fire regimes: lessons from reburns and research needs. Forest Ecology and Management. 396: 217-233. doi:10.1016/j.foreco.2017.03.035

Prichard, S.J.; Povak, N.A.; Kennedy, M.C.; Peterson, D.W. 2020. Fuel treatment effectiveness in the context of landform, vegetation, and large, wind-driven wildfires. Ecological Applications. 30(5): e02104 (22 p). doi:10.1002/eap.2104

Prober, S.M.; Dunlop, M. 2011. Climate change: a cause for new biodiversity conservation objectives but let's not throw the baby out with the bathwater. Ecological Management and Restoration. 12(1): 2-3. doi:10.1111/j.1442-8903-2011.00563.x

Progar, R.A.; Hrinkevich, K.H.; Clark, E.S.; Rinella, M.J. 2017. Prescribed burning in ponderosa pine: Fuel reductions and redistributing fuels near boles to prevent injury. Fire Ecology. 13(1): 149-161. doi:10.4996/fireecology.1301149

Pruyn, M.L.; Gartner, B.L.; Harmon, M.E. 2002. Respiratory potential in sapwood of old versus young ponderosa pine trees in the Pacific Northwest. Tree Physiology. 22(2-3): 105-116. doi:10.1093/treephys/22.2-3.105

Puettmann, K.J.; Coates, K.D.; Messier, C. 2009. A critique of silviculture: managing for complexity. Washington, DC: Island Press. 189 p. isbn:978-1-59726-146-3

Pugnaire, F.I.; Morillo, J.A.; Peñuelas, J.; Reich, P.B.; Bardgett, R.D.; Gaxiola, A.; Wardle, D.A.; van der Putten, W.H. 2019. Climate change effects on plant-soil feedbacks and consequences for biodiversity and functioning of terrestrial ecosystems. Science Advances. 5(11): eaaz1834 (12 p). doi:10.1126/sciadv.aaz1834

Puhlick, J.J.; Laughlin, D.C.; Moore, M.M. 2012. Factors influencing ponderosa pine regeneration in the southwestern USA. Forest Ecology and Management. 264: 10-19. doi:10.1016/j.foreco.2011.10.002

Putnam, B.J. 1983. Songbird populations of precommercially thinned and unthinned stands of ponderosa pine in east-central Washington. M.S. thesis. Corvallis, OR: Oregon State University. 58 p. http://ir.library.oregonstate.edu/xmlui/handle/1957/9355

Putz, F.E.; Parker, G.G.; Archibald, R.M. 1984. Mechanical abrasion and intercrown spacing. American Midland Naturalist. 112(1): 24-28. doi:10.2307/2425452

Pyne, S.J. 1997. America's fires: management on wildlands and forests. Durham, NC: Forest History Society. 54 p. isbn:0-89030-053-4

Pyne, S.J. 2008. Passing the torch: why the eons-old truce between humans and fire has burst into an age of megafires, and what can be done about it. American Scholar. 77(2): 22-32. Pyne 2008

Pyne, S.J.; Andrews, P.L.; Laven, R.D. 1996. Introduction to wildland fire. 2nd edition. New York: John Wiley & Sons. 769 p. isbn:0-471-54913-4

Quaempts, E.J.; Jones, K.L.; O'Daniel, S.J.; Beechie, T.J.; Poole, G.C. 2018. Aligning environmental management with ecosystem resilience: a First Foods example from the Confederated Tribes of the Umatilla Indian Reservation, Oregon, USA. Ecology and Society. 23(2): 29 (20 p). doi:10.5751/ES-10080-230229

Quigley, T.M. 1992. Forest health in the Blue Mountains: social and economic perspectives. Gen. Tech. Rep. PNW-GTR-296. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 9 p. http://www.treesearch.fs.fed.us/pubs/9033

Quigley, T.M.; Arbelbide, S.J., tech. eds. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 4 volumes; 2,066 p. https://www.fs.usda.gov/treesearch/pubs/24921

Quigley, T.M.; Haynes, R.W.; Graham, R.T. 1996. Integrated scientific assessment for ecosystem management in the interior Columbia basin. Gen. Tech. Rep. PNW-GTR-382. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 303 p. http://www.treesearch.fs.fed.us/pubs/25384

Quigley, T.M.; Hayes, J.L.; Starr, L.; Daterman, G.E. 2001. Improving forest health and productivity in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 234-251. http://hdl.handle.net/2376/999

Quinn-Davidson, L.N.; Varner, J.M. 2012. Impediments to prescribed fire across agency, landscape and manager: an example from northern California. International Journal of Wildland Fire. 21(3): 210-218. doi:10.1071/WF11017

Radwan, M.A.; Crouch, G.L.; Harrington, C.A.; Ellis, W.D. 1982. Terpenes of ponderosa pine and feeding preferences by pocket gophers. Journal of Chemical Ecology. 8(1): 241-253. doi:10.1007/bf00984020

Rainville, R.; White, R.; Barbour, J. 2008. Assessment of timber availability from forest restoration within the Blue Mountains of Oregon. Gen. Tech. Rep. PNW-GTR-752. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 65 p. http://www.treesearch.fs.fed.us/pubs/30559

Rancourt, S.J.; Rule, M.I.; O'Connell, M.A. 2007. Maternity roost site selection of big brown bats in ponderosa pine forests of the channeled scablands of northeastern Washington State, USA. Forest Ecology and Management. 248(3): 183-192. doi:10.1016/j.foreco.2007.05.005

Randall, J.M.; Rejmanek, M. 1993. Interference of bull thistle *(Cirsium vulgare)* with growth of ponderosa pine *(Pinus ponderosa)* seedlings in a forest plantation. Canadian Journal of Forest Research. 23(8): 1507-1513. doi:10.1139/x93-190

Rapp, V. 2002. Fire risk in east-side forests. Portland, OR: Science Update. 2: 1-11. http://www.fs.fed.us/pnw/scienceupdate2.pdf

Rasmussen, L.A. 1992. Top-kill of ponderosa pine, Dixie National Forest, Utah. Res. Note INT-407. Ogden, UT: USDA Forest Service, Intermountain Research Station. 3 p. https://archive.org/download/topkillofpondero407rasm/topkillofpondero407rasm.pdf

Ratcliff, T.D.; Patton, D.R.; Ffolliott, P.F. 1975. Ponderosa pine basal area and the Kaibab squirrel. Journal of Forestry. 73(5): 284-286. doi:10.1093/jof/73.5.284

Reaves, J.L.; Shaw, C.G., III; Martin, R.E.; Mayfield, J.E. 1984. Effects of ash leachates on growth and development of *Armillaria mellea* in culture. Res. Note PNW-418. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 11 p. https://www.fs.usda.gov/treesearch/pubs/26797

Reaves, J.L.; Shaw, C.G., III; Mayfield, J.E. 1990. The effects of *Trichoderma* spp. isolated from burned and non-burned forest soils on the growth and development of *Armillaria ostoyae* in culture. Northwest Science. 64(1): 39-44. http://hdl.handle.net/2376/1656

Regelbrugge, J.C.; Conard, S.G. 1993. Modeling tree mortality following wildfire in *Pinus ponderosa* forests in the central Sierra Nevada of California. International Journal of Wildland Fire. 3(3): 139-148. doi:10.1071/WF9930139

Rehfeldt, G.E. 1980. Genetic gains from tree improvement of ponderosa pine in southern Idaho. Res. Paper INT-263. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 9 p. https://archive.org/download/geneticgainsfrom263rehf/geneticgainsfrom263rehf.pdf

Rehfeldt, G.E. 1986. Adaptive variation in *Pinus ponderosa* from Intermountain regions. I. Snake and Salmon River basins. Forest Science. 32(1): 79-92. doi:10.1093/forestscience/32.1.79

Rehfeldt, G.E. 1987. Adaptive variation and seed transfer for ponderosa pine in central Idaho. Res. Note INT-373. Ogden, UT: USDA Forest Service, Intermountain Research Station. 6 p. https://archive.org/download/adaptivevariatio373rehf_0/adaptivevariatio373rehf_0.pdf

Rehfeldt, G.E. 1994. Evolutionary genetics, the biological species, and the ecology of the interior cedar-hemlock forests. In: Baumgartner, D.M.; Lotan, J.E.; Tonn, J.R., comps. Interior cedar-hemlock-white pine forests: ecology and management. Pullman, WA: Washington State University, Department of Natural Resource Sciences: 91-100.

Rehfeldt, G.E.; Crookston, N.L.; Warwell, M.V.; Evans, J.S. 2006. Empirical analyses of plant-climate relationships for the western United States. International Journal of Plant Sciences. 167(6): 1123-1150. doi:10.1086/507711

Rehfeldt, G.E.; Ferguson, D.E.; Crookston, N.L. 2009. Aspen, climate, and sudden decline in western USA. Forest Ecology and Management. 258(11): 2353-2364. doi:10.1016/j.foreco.2009.06.005

Rehfeldt, G.E.; Leites, L.P.; Bradley St Clair, J.; Jaquish, B.C.; Sáenz-Romero, C.; López-Upton, J.; Joyce, D.G. 2014a. Comparative genetic responses to climate in the varieties of *Pinus ponderosa* and *Pseudotsuga menziesii*: Clines in growth potential. Forest Ecology and Management. 324: 138-146. doi:10.1016/j.foreco.2014.02.041

Rehfeldt, G.E.; Jaquish, B.C.; López-Upton, J.; Sáenz-Romero, C.; St Clair, J.B.; Leites, L.P.; Joyce, D.G. 2014b. Comparative genetic responses to climate for the varieties of *Pinus ponderosa* and *Pseudotsuga menziesii*: Realized climate niches. Forest Ecology and Management. 324: 126-137. doi:10.1016/j.foreco.2014.02.035

Rehfeldt, G.E.; Jaquish, B.C.; Sáenz-Romero, C.; Joyce, D.G.; Leites, L.P.; Bradley St Clair, J.; López-Upton, J. 2014c. Comparative genetic responses to climate in the varieties of *Pinus ponderosa* and *Pseudotsuga menziesii*: Reforestation. Forest Ecology and Management. 324: 147-157. doi:10.1016/j.foreco.2014.02.040

Reich, R.M.; Mielke, P.W., Jr.; Hawksworth, F.G. 1991. Spatial analysis of ponderosa pine trees infected with dwarf mistletoe. Canadian Journal of Forest Research. 21(12): 1808-1815. doi:10.1139/x91-249

Reilly, M.J.; Dunn, C.J.; Meigs, G.W.; Spies, T.A.; Kennedy, R.E.; Bailey, J.D.; Briggs, K. 2017. Contemporary patterns of fire extent and severity in forests of the Pacific Northwest, USA (1985–2010). Ecosphere. 8(3): e01695 (28 p.). doi:10.1002/ecs2.1695

Reilly, M.J.; Elia, M.; Spies, T.A.; Gregory, M.J.; Sanesi, G.; Lafortezza, R. 2018. Cumulative effects of wildfires on forest dynamics in the eastern Cascade Mountains, USA. Ecological Applications. 28(2): 291-308. doi:10.1002/eap.1644

Reilly, M.J.; McCord, M.G.; Brandt, S.M.; Linowksi, K.P.; Butz, R.J.; Jules, E.S. 2020. Repeated, high-severity wildfire catalyzes invasion of non-native plant species in forests of the Klamath Mountains, northern California, USA. Biological Invasions. 22(6): 1821-1828. doi:10.1007/s10530-020-02227-3

Reimoser, F.; Gossow, H. 1996. Impact of ungulates on forest vegetation and its dependence on the silvicultural system. Forest Ecology and Management. 88(1-2): 107-119. doi:10.1016/S0378-1127(96)03816-9

Reimoser, F.; Armstrong, H.; Suchant, R. 1999. Measuring forest damage of ungulates: what should be considered. Forest Ecology and Management. 120(1-3): 47-58. doi:10.1016/S0378-1127(98)00542-8

Reineke, L.H. 1933. Perfecting a stand-density index for even-aged forests. Journal of Agricultural Research. 46(7): 627-638. https://naldc-legacy.nal.usda.gov/naldc/download.xhtml?id=IND43968212&content=PDF

Reiner, A.L.; Vaillant, N.M.; Fites-Kaufman, J.; Dailey, S.N. 2009. Mastication and prescribed fire impacts on fuels in a 25-year old ponderosa pine plantation, southern Sierra Nevada. Forest Ecology and Management. 258(11): 2365-2372. doi:10.1016/j.foreco.2009.07.050

Reinhardt, E.; Holsinger, L. 2010. Effects of fuel treatments on carbon-disturbance relationships in forests of the northern Rocky Mountains. Forest Ecology and Management. 259(8): 1427-1435. doi:10.1016/j.foreco.2010.01.015

Reinhardt, E.D.; Ryan, K.C. 1988. How to estimate tree mortality resulting from underburning. Fire Management Notes. 49(4): 30-36. https://www.fs.usda.gov/treesearch/pubs/58310

Reinhardt, T.E.; Ottmar, R.D.; Hanneman, A.J.S. 2000. Smoke exposure among firefighters at prescribed burns in the Pacific Northwest. Res. Paper PNW-RP-526. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 45 p. https://www.fs.usda.gov/treesearch/pubs/2940

Reinhardt, E.D.; Keane, R.E.; Calkin, D.E.; Cohen, J.D. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest Ecology and Management. 256(12): 1997-2006. doi:10.1016/j.foreco.2008.09.016

REO (Regional Ecosystem Office). 1995. Ecosystem analysis at the watershed scale: federal guide for watershed analysis. Version 2.2. Portland, OR: Regional Ecosystem Office. 26 p. https://www.fs.fed.us/r6/reo/library/docs/watershd.pdf

Restaino, J.C.; Peterson, D.L. 2013. Wildfire and fuel treatment effects on forest carbon dynamics in the western United States. Forest Ecology and Management. 303: 46-60. doi:10.1016/j.foreco.2013.03.043

Reynolds, H.G. 1966a. Slash cleanup in a ponderosa pine forest affects use by deer and cattle. Res. Note RM-64. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p. https://archive.org/download/CAT10236592/CAT10236592.pdf

Reynolds, H.G. 1966b. Use of a ponderosa pine forest in Arizona by elk, deer, and cattle. Res. Note RM-63. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p. Use_of_a_Ponderosa_Pine_Forest_in_Arizon

Reynolds, R.T.; Sánchez Meador, A.J.; Youtz, J.A.; Nicolet, T.; Matonis, M.S.; Jackson, P.L.; DeLorenzo, D.G.; Graves, A.D. 2013. Restoring composition and structure in southwestern frequent-fire forests: A science-based framework for improving ecosystem resiliency. Gen. Tech. Rep. RMRS-GTR-310. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 76 p. http://www.treesearch.fs.fed.us/pubs/44885

Rich, L.R. 1972. Managing a ponderosa pine forest to increase water yield. Water Resources Research. 8(2): 422-428. doi:10.1029/WR008i002p00422

Richards, B. 1992. As fires sear the west, Forest Service policies come under scrutiny. New York: The Wall Street Journal, Tuesday, October 6th, pages A1-A2, A9.

Richardson, D.M.; Rundel, P.W.; Jackson, S.T.; Teskey, R.O.; Aronson, J.; Bytnerowicz, A.; Wingfield, M.J.; Proches, S. 2007. Human impacts in pine forests: Past, present, and future. Annual Review of Ecology, Evolution, and Systematics. 38: 275-297. doi:10.1146/annurev.ecolsys.38.091206.095650

Riegel, G.M.; Miller, R.F.; Krueger, W.C. 1991. Understory vegetation response to increasing water and nitrogen levels in a *Pinus ponderosa* forest in northeastern Oregon. Northwest Science. 65(1): 10-15. http://hdl.handle.net/2376/1622

Riegel, G.M.; Miller, R.F.; Krueger, W.C. 1992. Competition for resources between understory vegetation and overstory *Pinus ponderosa* in northeastern Oregon. Ecological Applications. 2(1): 71-85. doi:10.2307/1941890

Riegel, G.M.; Miller, R.F.; Krueger, W.C. 1995. The effects of aboveground and belowground competition in a *Pinus ponderosa* forest. Forest Science. 41(4): 864-889. doi:10.1093/forestscience/41.4.864

Rieman, B.; Dunham, J.; Clayton, J. 2006. Emerging concepts for management of river ecosystems and challenges to applied integration of physical and biological sciences in the Pacific Northwest, USA. International Journal of River Basin Management. 4(2): 85-97. doi:10.1080/15715124.2006.9635279

Rietveld, W.J. 1975. Phytotoxic grass residues reduce germination and initial root growth of ponderosa pine. Res. Pap. RM-153. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p. https://www.fs.usda.gov/treesearch/pubs/23932

Rietveld, W.J. 1976. Cone maturation in ponderosa pine foliage scorched by wildfire. Res. Note RM-317. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p. Cone_maturation_in_ponderosa_pine_foliag

Rietveld, W.J. 1978. Forecasting seed crops and determining cone ripeness in southwestern ponderosa pine. Gen. Tech. Rep. RM-50. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p. Forecasting_Seed_Crops_and_Determining_C

Rietveld, W.J.; Heidmann, L.J. 1974. Mulching planted ponderosa pine seedlings in Arizona gives mixed results. Res. Note RM-257. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p. https://archive.org/download/CAT74417259/CAT74417259.pdf

Rietveld, W.J.; Heidmann, L.J. 1976. Direct seeding ponderosa pine on recent burns in Arizona. Res. Note RM-312. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p. https://archive.org/download/CAT76678331/CAT76678331.pdf

Riggs, R.A.; Tiedemann, A.R.; Cook, J.C.; Ballard, T.M.; Edgerton, P.J.; Vavra, M.; Krueger, W.C.; Hall, F.C.; Bryant, L.D.; Irwin, L.L.; Delcurto, T. 2000. Modification of mixed-conifer forests by ruminant herbivores in the Blue Mountains ecological province. Res. Pap. PNW-RP-527. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 77 p. http://www.treesearch.fs.fed.us/pubs/2941

Riling, J.; Geier-Hayes, K.; Jain, T. 2019. Decoupling the diameter–age debate: The Boise National Forest's legacy tree guide. Forest Science. 65(4): 519-527. doi:10.1093/forsci/fxz004

Ringo, C.; Bennett, K.; Noller, J.; Jiang, D.; Moore, D. 2018. Modeling droughty soils at regional scales in Pacific Northwest forests, USA. Forest Ecology and Management. 424: 121-135. doi:10.1016/j.foreco.2018.04.019

Rippy, R.C.; Stewart, J.E.; Zambino, P.J.; Klopfenstein, N.B.; Tirocke, J.M.; Kim, M.-S.; Thies, W.G. 2005. Root diseases in coniferous forests of the inland West: potential implications of fuel treatments. Gen. Tech. Rep. RMRS-GTR-141. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 32 p. http://www.treesearch.fs.fed.us/pubs/20469

Ritchie, M.W.; Knapp, E.E. 2014. Establishment of a long-term fire salvage study in an interior ponderosa pine forest. Journal of Forestry. 112(5): 395-400. doi:10.5849/jof.13-093

Ritchie, M.W.; Maguire, D.A.; Youngblood, A., tech. coords. 2005. Proceedings of the symposium on ponderosa pine: issues, trends, and management. Gen. Tech. Rep. PSW-GTR-198. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 281 p. http://www.treesearch.fs.fed.us/pubs/27253

Ritchie, M.W.; Skinner, C.N.; Hamilton, T.A. 2007. Probability of tree survival after wildfire in an interior pine forest of northern California: effects of thinning and prescribed fire. Forest Ecology and Management. 247(1-3): 200-208. doi:10.1016/j.foreco.2007.04.044

Ritchie, M.W.; Wing, B.M.; Hamilton, T.A. 2008. Stability of the large tree component in treated and untreated late-seral interior ponderosa pine stands. Canadian Journal of Forest Research. 38(5): 919-923. doi:10.1139/x07-242

Ritchie, M.; Zhang, J.; Hamilton, T. 2012. Effects of stand density on top height estimation for ponderosa pine. Western Journal of Applied Forestry. 27(1): 18-24. doi:10.1093/wjaf/27.1.18

Ritchie, M.W.; Knapp, E.E.; Skinner, C.N. 2013. Snag longevity and surface fuel accumulation following post-fire logging in a ponderosa pine dominated forest. Forest Ecology and Management. 287: 113-122. doi:10.1016/j.foreco.2012.09.001

Riitters, K.; Brodie, J.D.; Hann, D.W. 1982. Dynamic programming for optimization of timber production and grazing in ponderosa pine. Forest Science. 28(3): 517-526. doi:10.1093/forestscience/28.3.517

Robbins, W.G. 1997. Landscapes of promise: the Oregon story, 1800-1940. Seattle, WA: University of Washington Press. 392 p. isbn:0-295-97632-2

Robbins, W.G.; Wolf, D.W. 1994. Landscape and the intermontane northwest: an environmental history. Gen. Tech. Rep. PNW-GTR-319. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 32 p. http://www.treesearch.fs.fed.us/pubs/6224

Roberts, D.W.; Betz, D.W. 1999. Simulating landscape vegetation dynamics of Bryce Canyon National Park with the vital attributes/fuzzy systems model VAFS/LANDSIM. In: Mladenoff, D.J.; Baker, W.L., eds. Spatial modeling of forest landscape change: approaches and applications. Cambridge, UK: Cambridge University Press: 99-124. isbn:0-521-63122-X

Roberts, S.L.; van Wagtendonk, J.W.; Miles, A.K.; Kelt, D.A. 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. Biological Conservation. 144(1): 610-619. doi:10.1016/j.biocon.2010.11.002

Roberts, C.P.; Donovan, V.M.; Nodskov, S.M.; Keele, E.B.; Allen, C.R.; Wedin, D.A.; Twidwell, D. 2020. Fire legacies, heterogeneity, and the importance of mixed-severity fire in ponderosa pine savannas. Forest Ecology and Management. 459: 117853 (9 p). doi:10.1016/j.foreco.2019.117853

Robertson, P.A.; Bowser, Y.H. 1999. Coarse woody debris in mature *Pinus ponderosa* stands in Colorado. Journal of the Torrey Botanical Society. 126(3): 255-267. doi:10.2307/2997280

Robichaud, P.R. 2000. Fire effects on infiltration rates after prescribed fire in northern Rocky Mountain forests, USA. Journal of Hydrology. 231-232: 220-229. doi:10.1016/S0022-1694(00)00196-7

Robichaud, P.R.; Jordan, P.; Lewis, S.A.; Ashmun, L.E.; Covert, S.A.; Brown, R.E. 2013a. Evaluating the effectiveness of wood shred and agricultural straw mulches as a treatment to reduce post-wildfire hillslope erosion in southern British Columbia, Canada. Geomorphology. 197: 21-33. doi:10.1016/j.geomorph.2013.04.024

Robichaud, P.R.; Lewis, S.A.; Wagenbrenner, J.W.; Ashmun, L.E.; Brown, R.E. 2013b. Post-fire mulching for runoff and erosion mitigation: Part I: Effectiveness at reducing hillslope erosion rates. Catena. 105: 75-92. doi:10.1016/j.catena.2012.11.015

Rocca, M.E.; Brown, P.M.; MacDonald, L.H.; Carrico, C.M. 2014. Climate change impacts on fire regimes and key ecosystem services in Rocky Mountain forests. Forest Ecology and Management. 327: 290-305. doi:10.1016/j.foreco.2014.04.005

Roccaforte, J.P.; Fule, P.Z.; Covington, W.W. 2008. Landscape-scale changes in canopy fuels and potential fire behaviour following ponderosa pine restoration treatments. International Journal of Wildland Fire. 17(2): 293-303. doi:10.1071/WF06120

Roccaforte, J.P.; Fulé, P.Z.; Covington, W.W. 2010. Monitoring landscape-scale ponderosa pine restoration treatment implementation and effectiveness. Restoration Ecology. 18(6): 820-833. doi:10.1111/j.1526-100X.2008.00508.x

Roccaforte, J.P.; Fulé, P.Z.; Chancellor, W.W.; Laughlin, D.C. 2012. Woody debris and tree regeneration dynamics following severe wildfires in Arizona ponderosa pine forests. Canadian Journal of Forest Research. 42(3): 593-604. doi:10.1139/x2012-010

Roccaforte, J.P.; Huffman, D.W.; Fulé, P.Z.; Covington, W.W.; Chancellor, W.W.; Stoddard, M.T.; Crouse, J.E. 2015. Forest structure and fuels dynamics following ponderosa pine restoration treatments, White Mountains, Arizona, USA. Forest Ecology and Management. 337: 174-185. doi:10.1016/j.foreco.2014.11.001

Roccaforte, J.P.; Sánchez Meador, A.; Waltz, A.E.M.; Gaylord, M.L.; Stoddard, M.T.; Huffman, D.W. 2018. Delayed tree mortality, bark beetle activity, and regeneration dynamics five years following the Wallow Fire, Arizona, USA: Assessing trajectories towards resiliency. Forest Ecology and Management. 428: 20-26. doi:10.1016/j.foreco.2018.06.012

Rochelle, J.A.; Lehmann, L.A.; Wisniewski, J., eds. 1999. Forest fragmentation: wildlife and management implications. Leiden, Netherlands: Brill Academic Publishers. 301 p. isbn:90-04-11388-6

Rodman, K.C.; Sánchez Meador, A.J.; Moore, M.M.; Huffman, D.W. 2017. Reference conditions are influenced by the physical template and vary by forest type: A synthesis of *Pinus ponderosa*-dominated sites in the southwestern United States. Forest Ecology and Management. 404: 316-329. doi:10.1016/j.foreco.2017.09.012

Rodman, K.C.; Veblen, T.T.; Saraceni, S.; Chapman, T.B. 2019. Wildfire activity and land use drove 20th-century changes in forest cover in the Colorado Front Range. Ecosphere. 10(2): e02594 (27 p). doi:10.1002/ecs2.2594

Rodman, K.C.; Veblen, T.T.; Chapman, T.B.; Rother, M.T.; Wion, A.P.; Redmond, M.D. 2020. Limitations to recovery following wildfire in dry forests of southern Colorado and northern New Mexico, USA. Ecological Applications. 30(1): e02001 (20 p). doi:10.1002/eap.2001

Roe, A.L. 1947. The growth rate of selectively cut ponderosa pine in western Montana. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/CAT31013725/CAT31013725.pdf

Roe, A.L. 1951. Growth tables for selectively-cut ponderosa pine in western Montana. Station Paper No. 32. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 16 p. https://archive.org/download/growthtablesfors32roea/growthtablesfors32roea.pdf

Roe, A.L. 1952. Growth of selectively cut ponderosa pine stands in the upper Columbia Basin. Agric. Handbook No. 39. Washington, DC: USDA Forest Service. 29 p. https://naldc-legacy.nal.usda.gov/naldc/download.xhtml?id=CAT87208959&content=PDF

Roe, A.L.; Benson, R.E. 1966. Evaluating growth performance of young stands. Res. Note INT-44. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 7 p. https://archive.org/download/evaluatinggrowth44roea/evaluatinggrowth44roea.pdf

Roe, A.L.; Squillace, A.E. 1950. Can we induce prompt regeneration in selectively-cut ponderosa pine stands? Res. Note No. 81. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 7 p. https://archive.org/download/CAT31015276/CAT31015276.pdf

Roeser, J., Jr. 1940. The water requirement of Rocky Mountain conifers. Journal of Forestry. 38(1): 24-26. doi:10.1093/jof/38.1.24

Rogers, P.C.; St. Clair, S.B. 2016. Quaking aspen in Utah: Integrating recent science with management. Rangelands. 38(5): 266-272. doi:10.1016/j.rala.2016.08.009

Rogers, P.C.; Shepperd, W.D.; Bartos, D.L. 2007. Aspen in the Sierra Nevada: regional conservation of a continental species. Natural Areas Journal. 27(2): 183-193. doi:10.3375/0885-8608(2007)27[183:AITSNR]2.0.CO;2

Rollins, M.G.; Swetnam, T.W.; Morgan, P. 2001. Evaluating a century of fire patterns in two Rocky Mountain wilderness areas using digital fire atlases. Canadian Journal of Forest Research. 31(12): 2107-2123. doi:10.1139/x01-141

Rose, J.A.; Eddleman, L.E. 1994. Ponderosa pine and understory growth following western juniper removal. Northwest Science. 68(2): 79-85. http://hdl.handle.net/2376/1546

Rose, S.L.; Perry, D.A.; Pilz, D.; Schoeneberger, M.M. 1983. Allelopathic effects of litter on the growth and colonization of mycorrhizal fungi. Journal of Chemical Ecology. 9(8): 1153-1162. doi:10.1007/BF00982218

Rosenthal, D.H.; Edmonds, J.A.; Richards, K.R.; Wise, M.A. 1993. Stabilizing U.S. net carbon emissions by planting trees. Energy Conversion and Management. 34(9): 881-887. doi:10.1016/0196-8904(93)90032-6

Ross, R.L.; Hunter, H.E. 1976. Climax vegetation of Montana based on soils and climate. Bozeman, MT: USDA Soil Conservation Service. 64 p. https://archive.org/download/climaxvegetation00ross/climaxvegetation00ross.pdf

Ross, D.W.; Scott, W.; Heninger, R.L.; Walstad, J.D. 1986. Effects of site preparation on ponderosa pine (Pinus ponderosa), associated vegetation, and soil properties in south central Oregon. Canadian Journal of Forest Research. 16(3): 612-618. doi:10.1139/x86-105

Rossman, A.K.; Halpern, C.B.; Harrod, R.J.; Urgenson, L.S.; Peterson, D.W.; Bakker, J.D. 2018. Benefits of thinning and burning for understory diversity vary with spatial scale and time since treatment. Forest Ecology and Management. 419-420: 58-78. doi:10.1016/j.foreco.2018.03.006

Rossman, A.K.; Bakker, J.D.; Peterson, D.W.; Halpern, C.B. 2020. Long-term effects of fuels treatments, overstory structure, and wildfire on tree regeneration in dry forests of central Washington. Forests. 11(8): 888 (28 p). doi:10.3390/f11080888

Rotarangi, S.J.; Stephenson, J. 2014. Resilience pivots: Stability and identity in a social-ecological-cultural system. Ecology and Society. 19(1): 28 (10 p). doi:10.5751/ES-06262-190128

Roth, L.F. 1971. Dwarf mistletoe damage to small ponderosa pines. Forest Science. 17(3): 373-380. doi:10.1093/forestscience/17.3.373

Roth, L.F. 2001. Dwarf mistletoe-induced mortality in Northwest ponderosa pine growing stock. Western Journal of Applied Forestry. 16(3): 136-141. doi:10.1093/wjaf/16.3.136

Roth, L.F.; Shaw, C.G., III; Rolph, L. 1977. Marking ponderosa pine to combine commercial thinning and control of Armillaria root rot. Journal of Forestry. 75(10): 644-647. doi:10.1093/jof/75.10.644

Roth, L.F.; Rolph, L.; Cooley, S. 1980. Identifying infected ponderosa pine stumps to reduce costs of controlling Armillaria root rot. Journal of Forestry. 78(3): 145-148. doi:10.1093/jof/78.3.145

Roth, L.F.; Shaw, C.G., III; Rolph, L. 2000. Inoculation reduction measures to control Armillaria root disease in a severely infested stand of ponderosa pine in south-central Washington: 20 year results. Western Journal of Applied Forestry. 15(2): 92-100. doi:10.1093/wjaf/15.2.92

Rother, M.T.; Veblen, T.T. 2016. Limited conifer regeneration following wildfires in dry ponderosa pine forests of the Colorado Front Range. Ecosphere. 7(12): e01594 (17 p). doi:10.1002/ecs2.1594

Rother, M.T.; Veblen, T.T. 2017. Climate drives episodic conifer establishment after fire in dry ponderosa pine forests of the Colorado Front Range, USA. Forests. 8(5): 159 (16 p). doi:10.3390/f8050159

Rothman, H.K., ed. 1994. I'll never fight fire with my bare hands again: recollections of the first forest rangers of the inland northwest. Lawrence, KS: University Press of Kansas. 275 p. isbn:0-7006-0677-7

Rowe, J.S. 1992. The ecosystem approach to forestland management. Forestry Chronicle. 68(2): 222-224. doi:10.5558/tfc68222-2

Rummell, R.S. 1951. Some effects of livestock grazing on ponderosa pine forest and range in central Washington. Ecology. 32(4): 594-607. doi:10.2307/1932728

Rummer, B.; Prestemon, J.; May, D.; Miles, P.; Vissage, J.; McRoberts, R.; Liknes, G.; Shepperd, W.D.; Ferguson, D.; Elliot, W.; Miller, S.; Reutebuch, S.; Barbour, J.; Fried, J.; Stokes, B.; Bilek, E.; Skog, K. 2005. A strategic assessment of forest biomass and fuel reduction treatments in western states. Gen. Tech. Rep. RMRS-GTR-149. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 17 p. http://www.treesearch.fs.fed.us/pubs/8478

Running, S.W. 2006. Is global warming causing more, larger wildfires? Science. 313(5789): 927-928. doi:10.1126/science.1130370

Rupp, D.E.; Abatzoglou, J.T.; Mote, P.W. 2017. Projections of 21st century climate of the Columbia River Basin. Climate Dynamics. 49(5): 1783-1799. doi:10.1007/s00382-016-3418-7

Ryan, M.G.; Covington, W.W. 1986. Effect of a prescribed burn in ponderosa pine on inorganic nitrogen concentrations of mineral soil. Res. Note RM-464. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 5 p. Effect_of_a_Prescribed_Burn_in_Ponderosa

Ryan, K.C.; Frandsen, W.H. 1991. Basal injury from smoldering fires in mature *Pinus ponderosa* Laws. International Journal of Wildland Fire. 1(2): 107-118. doi:10.1071/WF9910107

Ryan, K.C.; Knapp, E.E.; Varner, J.M. 2013. Prescribed fire in North American forests and woodlands: history, current practice, and challenges. Frontiers in Ecology and the Environment. 11(s1): e15-e24. doi:10.1890/120329

Saab, V.A.; Dudley, J.G. 1998. Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho. Res. Paper RMRS-RP-11. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 17 p. https://www.fs.usda.gov/treesearch/pubs/23853

Saab, V.; Bate, L.; Lehmkuhl, J.; Dickson, B.; Story, S.; Jentsch, S.; Block, W. 2006. Changes in downed wood and forest structure after prescribed fire in ponderosa pine forests. In: Andrews, P.L.; Butler, B.W. Fuels management—how to measure success: conference proceedings. Proceedings RMRS-P-41. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 477-487. https://www.fs.usda.gov/treesearch/pubs/25971

Sabo, K.E.; Sieg, C.H.; Hart, S.C.; Bailey, J.D. 2009. The role of disturbance severity and canopy closure on standing crop of understory plant species in ponderosa pine stands in northern Arizona, USA. Forest Ecology and Management. 257(8): 1656-1662. doi:10.1016/j.foreco.2009.01.006

Sackett, S.S. 1980. Reducing natural ponderosa pine fuels using prescribed fire: two case studies. Res. Note RM-392. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 6 p. Reducing_Natural_Ponderosa_Pine_Fuels_Us

Sackett, S.S. 1984. Observations on natural regeneration in ponderosa pine following a prescribed fire in Arizona. Res. Note RM-435. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p. Observations_on_Natural_Regeneration

Sackett, S.S.; Haase, S.M.; Harrington, M.G. 1996. Lessons learned from fire use for restoring southwestern ponderosa pine ecosystems. In: Covington, W.; Wagner, P.K. Conference on adaptive ecosystem restoration and management: restoration of cordilleran conifer landscapes of North America. Gen. Tech. Rep. RM-GTR-278. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 54-61. https://archive.org/download/CAT10754548/CAT10754548.pdf

Safranyik, L.; Nevill, R.; Morrison, D. 1998. Effects of stand density management on forest insects and diseases. Tech. Tran. Note No. 12. Victoria, BC: Natural Resources Canada, Canadian Forest Service, Pacific Forestry Center. 4 p. http://bookstore.cfs.nrcan.gc.ca/detail_e.php?recid=35719

SAF Task Force. 2011. Forest carbon stocks and flows. Journal of Forestry. 109(Suppl_1): S14-S20. doi:10.1093/jof/109.s1.S14

Saigo, B.W. 1969. The relationship of non-recovered rodent caches to the natural regeneration of ponderosa pine. M.A. thesis. Corvallis, OR: Oregon State University, Department of Zoology. 98 p. http://ir.library.oregonstate.edu/xmlui/handle/1957/8372

Sala, A.; Peters, G.D.; McIntyre, L.R.; Harrington, M.G. 2005. Physiological responses of ponderosa pine in western Montana to thinning, prescribed fire and burning season. Tree Physiology. 25(3): 339-348. doi:10.1093/treephys/25.3.339

Salerno, J.; Huber-Stearns, H.; Jacobson, K.; Ellison, A.; Moseley, C. 2017. Monitoring restoration progress on Oregon's eastside national forests during the federal forest restoration program. Working Paper Number 79. Eugene, OR: University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program. 33 p. https://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/WP_79.pdf

Sallabanks, R.; Riggs, R.A.; Cobb, L.E. 2002. Bird use of forest structural classes in grand fir forests of the Blue Mountains, Oregon. Forest Science. 48(2): 311-321. doi:10.1093/forestscience/48.2.311

Sallabanks, R.; Christoffersen, N.D.; Weatherford, W.W.; Anderson, R. 2005. Restoring high priority habitats for birds: Aspen and pine in the interior West. In: Ralph, C.J.; Rich, T.D., eds. Bird conservation implementation and integration in the americas: Proceedings of the third international Partners In Flight conference. Volume 1, Gen. Tech. Rep. PSW-GTR-191. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 391-404. https://www.fs.usda.gov/treesearch/pubs/31708

Samman, S.; Wilson, B.L.; Hipkins, V.D. 2000. Genetic variation in Pinus ponderosa, Purshia tridentata, and Festuca idahoensis, community-dominant plants of California's yellow pine forest. Madroño. 47(3): 164-173.

Sampson, R.N.; Adams, D.L., eds. 1994. Assessing forest ecosystem health in the inland west. Binghamton, NY: Food Products Press (Haworth Press). 461 p. isbn:1-56022-052-X

Sampson, R.N.; Adams, D.L.; Hamilton, S.S.; Mealey, S.P.; Steele, R.; Van De Graaff, D. 1994. Assessing forest ecosystem health in the inland west. Journal of Sustainable Forestry. 2(1/2): 3-10. doi:10.1300/J091v02n01_01

Sanchez-Martinez, G.; Wagner, M.R. 2002. Bark beetle community structure under four ponderosa pine forest stand conditions in northern Arizona. Forest Ecology and Management. 170(1-3): 145-160. doi:10.1016/S0378-1127(01)00771-X

Sánchez Meador, A.J.; Moore, M.M. 2010. Lessons from long-term studies of harvest methods in southwestern ponderosa pine–Gambel oak forests on the Fort Valley Experimental Forest, Arizona, U.S.A. Forest Ecology and Management. 260(2): 193-206. doi:10.1016/j.foreco.2010.04.016

Sánchez Meador, A.J.; Moore, M.M.; Bakker, J.D.; Parysow, P.F. 2009. 108 years of change in spatial pattern following selective harvest of a *Pinus ponderosa* stand in northern Arizona, USA. Journal of Vegetation Science. 20(1): 79-90. doi:10.1046/j.1365-2893.1999.00142.x-i1

Sánchez Meador, A.J.; Parysow, P.F.; Moore, M.M. 2010. Historical stem-mapped permanent plots increase precision of reconstructed reference data in ponderosa pine forests of northern Arizona. Restoration Ecology. 18(2): 224-234. doi:10.1111/j.1526-100X.2008.00442.x

Sánchez Meador, A.J.; Parysow, P.F.; Moore, M.M. 2011. A new method for delineating tree patches and assessing spatial reference conditions of ponderosa pine forests in northern Arizona. Restoration Ecology. 19(4): 490-499. doi:10.1111/j.1526-100X.2010.00652.x

Sánchez Meador, A.J.; Waring, K.M.; Kalies, E.L. 2015. Implications of diameter caps on multiple forest resource responses in the context of the Four Forests Restoration Initiative: Results from the Forest Vegetation Simulator. Journal of Forestry. 113(2): 219-230. doi:10.5849/jof.14-021

Santo, A.; Davis, E.J.; Huber-Stearns, H.; Ellison, A. 2018. Successes, challenges, and opportunities for collaborative accelerated restoration in Oregon's Blue Mountains. Working Paper Number 88. Eugene, OR: University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program. 21 p. http://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/WP_88.pdf

Santoro, A.E.; Lombardero, M.J.; Ayres, M.P.; Ruel, J.J. 2001. Interactions between fire and bark beetles in an old growth pine forest. Forest Ecology and Management. 144(1-3): 245-254. doi:10.1016/S0378-1127(00)00389-3

Sartwell, C. 1970. *Ips pini* attack density in ponderosa pine thinning slash as related to felling date in eastern Oregon. Res. Note PNW-131. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p. https://archive.org/download/ipspiniattackden131sart/ipspiniattackden131sart.pdf

Sartwell, C. 1971. Thinning ponderosa pine to prevent outbreaks of mountain pine beetle. In: Baumgartner, D.M., ed. Precommercial thinning of coastal and intermountain forests in the Pacific Northwest. Pullman, WA: Washington State University, College of Agriculture, Cooperative Extension Service: 41-52.

Sartwell, C.; Dolph, R.E., Jr. 1976. Silvicultural and direct control of mountain pine beetle in second-growth ponderosa pine. Res. Note PNW-268. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p. https://archive.org/download/silviculturaldir268sart/silviculturaldir268sart.pdf

Sartwell, C.; Stevens, R.E. 1975. Mountain pine beetle in ponderosa pine: prospects for silvicultural control in second-growth stands. Journal of Forestry. 73(3): 136-140. doi:10.1093/jof/73.3.136

Sassaman, R.W.; Fight, R.D. 1975. A tool for estimating the financial returns on forage grasses seeded in thinned ponderosa pine. Journal of Range Management. 28(3): 185-189. https://journals.uair.arizona.edu/index.php/jrm/article/download/6437/6047

Sassaman, R.W.; Barrett, J.W; Smith, J.G. 1972. Economics of thinning stagnated ponderosa pine sapling stands in the pinegrass areas of central Washington. Res. Pap. PNW-144. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 17 p. https://www.fs.usda.gov/treesearch/pubs/26266

Sassaman, R.W.; Barrett, J.W.; Twombly, A.D. 1977. Financial precommercial thinning guides for northwest ponderosa pine stands. Res. Pap. PNW-226. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 27 p. Financial_precommerical_thinning_guides

Savage, M. 1991. Structural dynamics of a southwestern pine forest under chronic human influence. Annals of the Association of American Geographers. 81(2): 271-289. doi:10.1111/j.1467-8306.1991.tb01690.x

Savage, M.; Mast, J.N. 2005. How resilient are southwestern ponderosa pine forests after crown fires? Canadian Journal of Forest Research. 35(4): 967-977. doi:10.1139/x05-028

Savage, M.; Swetnam, T.W. 1990. Early 19th-century fire decline following sheep pasturing in a Navajo ponderosa pine forest. Ecology. 71(6): 2374-2378. doi:10.2307/1938649

Savage, M.; Brown, P.M.; Feddema, J. 1996. The role of climate in a pine forest regeneration pulse in the southwestern United States. Ecoscience. 3(3): 310-318. doi:10.1080/11956860.1996.11682348

Savage, M.; Mast, J.N.; Feddema, J.J. 2013. Double whammy: high-severity fire and drought in ponderosa pine forests of the Southwest. Canadian Journal of Forest Research. 43(6): 570-583. doi:10.1139/cjfr-2012-0404

Saxe, S.; Hogue, T.S.; Hay, L. 2018. Characterization and evaluation of controls on post-fire streamflow response across western US watersheds. Hydrology and Earth System Sciences. 22(2): 1221-1237. doi:10.5194/hess-22-1221-2018

Schaedel, M.S.; Larson, A.J.; Affleck, D.L.R.; Belote, R.T.; Goodburn, J.M.; Page-Dumroese, D.S. 2017. Early forest thinning changes aboveground carbon distribution among pools, but not total amount. Forest Ecology and Management. 389(Supplement C): 187-198. doi:10.1016/j.foreco.2016.12.018

Scharpf, R.F.; Roth, L.F. 1992. Resistance of ponderosa pine to western dwarf mistletoe in central Oregon. Res. Paper PSW-RP-208. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 9 p. https://www.fs.usda.gov/treesearch/pubs/29099

Scheffer, M.; Carpenter, S.; Foley, J.A.; Folke, C.; Walker, B. 2001. Catastrophic shifts in ecosystems. Nature. 413(6856): 591-596. doi:10.1038/35098000

Schmid, J.M.; Mata, S.A. 1992. Stand density and mountain pine beetle-caused tree mortality in ponderosa pine stands. Res. Note RM-515. Fort Collins, CO: USDA Forest Service, Rocky

Mountain Forest and Range Experiment Station. 4 p.

Schmid, J.M.; Mata, S.A.; McCambridge, W.F. 1985. Natural falling of beetle-killed ponderosa pine. Res. Note RM-454. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.

Schmid, J.M.; Mata, S.A.; Averill, R.D. 1989. Containment of small group infestations of the mountain pine beetle in ponderosa pine. Res. Note RM-493. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/containmentofsma493schm/containmentofsma493schm.pdf

Schmid, J.M.; Mata, S.A.; Schmidt, R.A. 1991a. Bark temperature patterns in ponderosa pine stands and their possible effects on mountain pine beetle behavior. Canadian Journal of Forest Research. 21(10): 1439-1446. doi:10.1139/x91-203

Schmid, J.M.; Mata, S.A.; Watkins, R.K.; Kaufmann, M.R. 1991b. Water potential in ponderosa pine stands of different growing-stock levels. Canadian Journal of Forest Research. 21(6): 750-755. doi:10.1139/x91-107

Schmid, J.M.; Mata, S.A.; Allen, D.C. 1992. Potential influences of horizontal and vertical air movement in ponderosa pine stands on mountain pine beetle dispersal. Res. Note RM-516. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. Potential_Influences_of_Horizontal_and_V

Schmid, J.M.; Mata, S.A.; Obedzinski, R.A. 1994. Hazard rating ponderosa pine stands for mountain pine beetles in the Black Hills. Res. Note RM-529. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/hazardratingpond529schm/hazardratingpond529schm.pdf

Schmid, J.M.; Mata, S.A.; Olsen, W.K. 1995. Microclimate and mountain pine beetles in two ponderosa pine stands in the Black Hills. Res. Note RM-RN-532. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p. https://archive.org/download/microclimatemoun532schm/microclimatemoun532schm.pdf

Schmidt, W.C.; Shearer, R.C. 1971. Ponderosa pine seed – for animals or trees? Res. Paper INT-112. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 14 p. https://archive.org/download/ponderosapinesee112schm/ponderosapinesee112schm.pdf

Schmidt, T.; Boche, M.; Blackwood, J.; Richmond, B. 1993. Blue Mountains ecosystem restoration strategy: a report to the Regional Forester. Unnum. Rep. Portland, OR: USDA Forest Service, Pacific Northwest Region. 12 p (plus appendices).

Schmidt, K.M.; Menakis, J.P.; Hardy, C.C.; Hann, W.J.; Bunnell, D.L. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. Gen. Tech. Rep. RMRS-GTR-87. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 41 p (+CD). http://www.treesearch.fs.fed.us/pubs/4590

Schmidt, L.; Hille, M.G.; Stephens, S.L. 2006. Restoring northern Sierra Nevada mixed conifer forest composition and structure with prescribed fires of varying intensities. Fire Ecology. 2(2): 20-33. doi:10.4996/fireecology.0202020

Schmitt, C.L. 1996. Management of ponderosa pine infected with western dwarf mistletoe in northeastern Oregon. Management Guide BMZ-96-07. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Blue Mountains Pest Management Service Center. 24 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_026033.pdf

Schmitt, C.L. 1997. Management of Douglas-fir infected with dwarf mistletoe in the Blue Mountains of northeastern Oregon and southeastern Washington. Management Guide BMZ-97-02. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Blue Mountains Pest Management Service Center. 26 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_026324.pdf

Schmitt, C.L.; Powell, D.C. 2005. Rating forest stands for insect and disease susceptibility: a simplified approach; version 2.0. Pub. BMPMSC-05-01. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Blue Mountains Pest Management Service Center. 20 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015659.pdf

Schmitt, C.L.; Powell, D.C. 2012. Range of variation recommendations for insect and disease susceptibility. White Pap. F14-SO-WP-Silv-22. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 12 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5358588.pdf

Schmitt, C.L.; Parmeter, J.R.; Kliejunas, J.T. 2000. Annosus root disease of western conifers. Forest Insect and Disease Leaflet 172; R6-NR-FID-PR-002-00. [Place of publication unknown]: USDA Forest Service. 9 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043457.pdf

Schneider, W.G.; Knowe, S.A.; Harrington, T.B. 1998. Predicting survival of planted Douglas-fir and ponderosa pine seedlings on dry, low-elevation sites in southwestern Oregon. New Forests. 15(2): 139-159. doi:10.1023/A:1006523404870

Schneider, E.E.; Sánchez Meador, A.J.; Covington, W.W. 2016. Reference conditions and historical changes in an unharvested ponderosa pine stand on sedimentary soil. Restoration Ecology. 24(2): 212-221. doi:10.1111/rec.12296

Schneider, E.E.; Affleck, D.L.R.; Larson, A.J. 2019. Tree spatial patterns modulate peak snow accumulation and snow disappearance. Forest Ecology and Management. 441: 9-19. doi:10.1016/j.foreco.2019.03.031

Schoennagel, T.; Balch, J.K.; Brenkert-Smith, H.; Dennison, P.E.; Harvey, B.J.; Krawchuk, M.A.; Mietkiewicz, N.; Morgan, P.; Moritz, M.A.; Rasker, R.; Turner, M.G.; Whitlock, C. 2017. Adapt to more wildfire in western North American forests as climate changes. Proceedings of the National Academy of Sciences of the United States of America. 114(18): 4582-4590. doi:10.1073/pnas.1617464114

Schowalter, T.; Withgott, J. 2001. Rethinking insects: What would an ecosystem approach look like? Conservation Biology In Practice. 2(4): 10-16. doi:10.1111/j.1526-4629.2001.tb00017.x

Schubert, G.H. 1971. Growth response of even-aged ponderosa pines related to stand density levels. Journal of Forestry. 69(12): 857-860. doi:10.1093/jof/69.12.857

Schubert, G.H. 1974. Silviculture of southwestern ponderosa pine: the status of our knowledge. Res. Pap. RM-123. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 71 p. https://www.fs.usda.gov/treesearch/pubs/35043

Schultz, A.M.; Biswell, H.H. 1959. Effect of prescribed burning and other seedbed treatments on ponderosa pine seedling emergence. Journal of Forestry. 57(11): 816-817. doi:10.1093/jof/57.11.816

Schultz, C.A.; Moseley, C. 2019. Collaborations and capacities to transform fire management. Science. 366(6461): 38-40. doi:10.1126/science.aay3727

Schultz, C.A.; Sisk, T.D.; Noon, B.R.; Nie, M.A. 2013. Wildlife conservation planning under the

United States Forest Service's 2012 planning rule. Journal of Wildlife Management. 77(3): 428-444. doi:10.1002/jwmg.513

Schultz, C.; Huber-Stearns, H.; McCaffrey, S.; Quirke, D.; Ricco, G.; Moseley, C. 2018. Prescribed fire policy barriers and opportunities: A diversity of challenges and strategies across the West. Working Paper Number 86. Eugene, OR: University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program. 33 p. https://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/WP_86.pdf

Schuster, J.L. 1964. Root development of native plants under three grazing intensities. Ecology. 45(1): 63-70. doi:10.2307/1937107

Schwilk, D.W.; Knapp, E.E.; Ferrenberg, S.M.; Keeley, J.E.; Caprio, A.C. 2006. Tree mortality from fire and bark beetles following early and late season prescribed fires in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management. 232(1-3): 36-45. doi:10.1016/j.foreco.2006.05.036

Schwilk, D.W.; Keeley, J.E.; Knapp, E.E.; McIver, J.; Bailey, J.D.; Fettig, C.J.; Fiedler, C.E.; Harrod, R.J.; Moghaddas, J.J.; Outcalt, K.W.; Skinner, C.N.; Stephens, S.L.; Waldrop, T.A.; Yaussy, D.A.; Youngblood, A. 2009. The national Fire and Fire Surrogate study: effects of fuel reduction methods on forest vegetation structure and fuels. Ecological Applications. 19(2): 285-304. doi:10.1890/07-1747.1

Scott, L.M. 1928. Indian diseases as aids to Pacific Northwest settlement. Oregon Historical Quarterly. 29(2): 144-161. http://www.jstor.org/stable/20610412

Scott, V.E. 1978. Characteristics of ponderosa pine snags used by cavity-nesting birds in Arizona. Journal of Forestry. 76(1): 26-28. doi:10.1093/jof/76.1.26

Scott, V.E. 1979. Bird response to snag removal in ponderosa pine. Journal of Forestry. 77(1): 26-28. doi:10.1093/jof/77.1.26

Scott, J.H. 1998a. Fuel reduction in residential and scenic forests: a comparison of three treatments in a western Montana ponderosa pine stand. Res. Pap. RMRS-RP-5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 19 p. https://www.fs.usda.gov/treesearch/pubs/31977

Scott, J. 1998b. Reduce fire hazards in ponderosa pine by thinning. Fire Management Notes. 58(1): 20-25. http://www.fs.fed.us/fire/fmt/fmt_pdfs/fmn58-1.pdf

Scott, D.W. 2005. Fire effects and delayed mortality of mature ponderosa pine. Tech. Transfer Paper BMPMSC-TTP-05-02. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Blue Mountain Pest Management Service Center. 8 p.

Scott, D.W. 2012. Pine butterfly. Forest Insect & Disease Leaflet 66; FS/R6/RO/FIDL#66-12/002. Portland, OR: USDA Forest Service, Pacific Northwest Region. 16 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5393938.pdf

Scott, J.H.; Reinhardt, E.D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Res. Pap. RMRS-RP-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 59 p. http://www.treesearch.fs.fed.us/pubs/4623

Scott, D.W.; Szymoniak, J.; Rockwell, V. 1996. Entomological concerns regarding burn characteristics and fire effects on tree species during prescribed landscape burns: burn severity guidelines and mitigation measures to minimize fire injuries. BMZ-97-1. Baker City, OR: USDA Forest Service, Pacific Northwest Region, Blue Mountain Pest Management Zone, Wallowa-Whitman National Forest. 49 p.

Scudieri, C.A.; Sieg, C.H.; Haase, S.M.; Thode, A.E.; Sackett, S.S. 2010. Understory vegetation response after 30 years of interval prescribed burning in two ponderosa pine sites in northern Arizona, USA. Forest Ecology and Management. 260(12): 2134-2142. doi:10.1016/j.foreco.2010.09.005

Sedell, J.R.; Leone, F.N.; Duval, W.S. 1991. Water transportation and storage of logs. In: Meehan, W.R., ed. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. Bethesda, MD: American Fisheries Society: 325-368.

Seidel, K.W. 1985. A ponderosa pine-grand fir spacing study in central Oregon: results after 10 years. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 7 p. https://www.fs.usda.gov/treesearch/pubs/26840

Seidel, K.W. 1986. Tolerance of seedlings of ponderosa pine, Douglas-fir, grand fir, and Engelmann spruce for high temperatures. Northwest Science. 60(1): 1-7. http://hdl.handle.net/2376/1778

Seidel, K.W. 1989. A ponderosa pine-lodgepole pine spacing study in central Oregon: results after 20 years. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 14 p. A_Ponderosa_Pine_lodgepole_Pine_Spacing

Seidel, K.W.; Cochran, P.H. 1981. Silviculture of mixed conifer forests in eastern Oregon and Washington. Gen. Tech. Rep. PNW-121. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 70 p. http://www.fs.fed.us/pnw/pubs/pnw_gtr121.pdf

Seidl, R.; Lexer, M.J. 2013. Forest management under climatic and social uncertainty: Trade-offs between reducing climate change impacts and fostering adaptive capacity. Journal of Environmental Management. 114: 461-469. doi:10.1016/j.jenvman.2012.09.028

Seidl, R.; Rammer, W.; Spies, T.A. 2014. Disturbance legacies increase the resilience of forest ecosystem structure, composition, and functioning. Ecological Applications. 24(8): 2063-2077. doi:10.1890/14-0255.1

Seidl, R.; Spies, T.A.; Peterson, D.L.; Stephens, S.L.; Hicke, J.A. 2016a. Searching for resilience: Addressing the impacts of changing disturbance regimes on forest ecosystem services. Journal of Applied Ecology. 53(1): 120-129. doi:10.1111/1365-2664.12511

Seidl, R.; Donato, D.C.; Raffa, K.F.; Turner, M.G. 2016b. Spatial variability in tree regeneration after wildfire delays and dampens future bark beetle outbreaks. Proceedings of the National Academy of Sciences. 113(46): 13075-13080. doi: 10.1073/pnas.1615263113

Seidl, R.; Thom, D.; Kautz, M.; Martin-Benito, D.; Peltoniemi, M.; Vacchiano, G.; Wild, J.; Ascoli, D.; Petr, M.; Honkaniemi, J.; Lexer, M.J.; Trotsiuk, V.; Mairota, P.; Svoboda, M.; Fabrika, M.; Nagel, T.A.; Reyer, C.P.O. 2017. Forest disturbances under climate change. Nature Climate Change. 7: 395-402. doi:10.1038/nclimate3303

Seidl, R.; Albrich, K.; Thom, D.; Rammer, W. 2018. Harnessing landscape heterogeneity for managing future disturbance risks in forest ecosystems. Journal of Environmental Management. 209: 46-56. doi:10.1016/j.jenvman.2017.12.014

Sesnie, S.; Bailey, J. 2003. Using history to plan the future of old-growth ponderosa pine. Journal of Forestry. 101(7): 40-47. doi:10.1093/jof/101.7.40

Sessions, J.; Smith, D.; Trippe, K.M.; Fried, J.S.; Bailey, J.D.; Petitmermet, J.H.; Hollamon, W.; Phillips, C.L.; Campbell, J.D. 2019. Can biochar link forest restoration with commercial agriculture? Biomass and Bioenergy. 123: 175-185. doi: 10.1016/j.biombioe.2019.02.015

Sexton, T.O. 1998. Ecological effects of post-wildfire management activities (salvage-logging and grass-seeding) on vegetation composition, diversity, biomass, and growth and survival of *Pinus ponderosa* and *Purshia tridentata*. M.S. thesis. Corvallis, OR: Oregon State University, Rangeland Resources. 121 p. https://ir.library.oregonstate.edu/xmlui/handle/1957/9596?show=full

Seymour, R.S.; Hunter, M.L., Jr. 1999. Principles of ecological forestry. Chapter 2. In: Hunter, M.L., Jr., ed. Maintaining biodiversity in forest ecosystems. Cambridge, UK: Cambridge University Press: 22-61. isbn:0-521-63768-6

Shakesby, R.A.; Doerr, S.H. 2006. Wildfire as a hydrological and geomorphological agent. Earth-Science Reviews. 74(3): 269-307. doi:10.1016/j.earscirev.2005.10.006

Shaw, D.C.; Oester, P.T.; Filip, G.M. 2009. Managing insects and diseases of Oregon conifers. EM 8980. [Corvallis, OR]: Oregon State University, Extension Service. 98 p. https://catalog.extension.oregonstate.edu/em8980

Shaw, M.R.; Pendleton, L.; Cameron, D.R.; Morris, B.; Bachelet, D.; Klausmeyer, K.; MacKenzie, J.; Conklin, D.R.; Bratman, G.N.; Lenihan, J.; Haunreiter, E.; Daly, C.; Roehrdanz, P.R. 2011. The impact of climate change on California's ecosystem services. Climatic Change. 109(Supplement 1): 465-484. doi:10.1007/s10584-011-0313-4

Shea, K.R. 1964. Diameter increment of ponderosa pine infected with dwarfmistletoe in south-central Oregon. Journal of Forestry. 62(10): 743-748. doi:10.1093/jof/62.10.743

Shea, R.W. 1993. Effects of prescribed fire and silvicultural activities on fuel mass and nitrogen redistribution in *Pinus ponderosa* ecosystems of central Oregon. M.S. thesis. Corvallis, OR: Oregon State University. 163 p. https://ir.library.oregonstate.edu/downloads/sf268952q

Shearer, R.C.; Schmidt, W.C. 1970. Natural regeneration in ponderosa pine forests of western Montana. Res. Pap. INT-86. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 20 p. https://archive.org/download/naturalregenerat86shea/naturalregenerat86shea.pdf

Shearer, R.C.; Schmidt, W.C. 1971. Ponderosa pine cone and seed losses. Journal of Forestry. 69(6): 370-372. doi:10.1093/jof/69.6.370

Sheehan, K.A. 1996. Defoliation by western spruce budworm in Oregon and Washington from 1980 through 1994. Tech. Pub. R6-NR-TP-04-96. Portland, OR: USDA Forest Service, Pacific Northwest Region. Irregular pagination. Sheehan 1996

Shepperd, W.D.; Battaglia, M.A. 2002. Ecology, silviculture, and management of Black Hills ponderosa pine. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 112 p. https://www.fs.usda.gov/treesearch/pubs/4816

Shepperd, W.D.; Edminster, C.B.; Mata, S.A. 2006. Long-term seedfall, establishment, survival, and growth of natural and planted ponderosa pine in the Colorado Front Range. Western Journal of Applied Forestry. 21(1): 19-26. doi:10.1093/wjaf/21.1.19

Sherich, K.; Pocewicz, A.; Morgan, P. 2007. Canopy characteristics and growth rates of ponderosa pine and Douglas-fir at long-established forest edges. Canadian Journal of Forest Research. 37(11): 2096-2105. doi:10.1139/X07-105

Sherman, R.J.; Chilcote, W.W. 1972. Spatial and chronological patterns of *Purshia tridentata* as influenced by *Pinus ponderosa*. Ecology. 53(2): 294-298. doi:10.2307/1934085

Sherriff, R.L.; Veblen, T.T. 2006. Ecological effects of changes in fire regimes in *Pinus ponderosa* ecosystems in the Colorado Front Range. Journal of Vegetation Science. 17(6): 705-718. doi:10.1111/j.1654-1103.2006.tb02494.x

Sherriff, R.L.; Veblen, T.T. 2008. Variability in fire-climate relationships in ponderosa pine forests in the Colorado Front Range. International Journal of Wildland Fire. 17(1): 50-59. doi:10.1071/WF07029

Shiflet, T.N., ed. 1994. Rangeland cover types of the United States. Denver, CO: Society for Range Management. 152 p. isbn:1-884930-01-8

Shifley, S.R.; Thompson III, F.R.; Dijak, W.D.; Fan, Z. 2008. Forecasting landscape-scale, cumulative effects of forest management on vegetation and wildlife habitat: a case study of issues, limitations, and opportunities. Forest Ecology and Management. 254(3): 474-483. doi:10.1016/j.foreco.2007.08.030

Shindler, B.; Reed, M. 1996. Forest management in the Blue Mountains: public perspectives on prescribed fire and mechanical thinning. Corvallis, OR: Oregon State University, Department of Forest Resources. 69 p. https://www.fs.usda.gov/treesearch/pubs/35279

Shindler, B.; Toman, E. 2003. Fuel reduction strategies in forest communities: a longitudinal analysis of public support. Journal of Forestry. 101(6): 8-14. doi:10.1093/jof/101.6.8

Shinn, D.A. 1980. Historical perspectives on range burning in the inland Pacific Northwest. Journal of Range Management. 33(6): 415-423. https://journals.uair.arizona.edu/index.php/jrm/article/download/7102/6714

Shinneman, D.J.; Baker, W.L. 1997. Nonequilibrium dynamics between catastrophic disturbances and old-growth forests in ponderosa pine landscapes of the Black Hills. Conservation Biology. 11(6): 1276-1288. doi:10.1046/j.1523-1739.1997.96198.x

Shinneman, D.J.; Baker, W.L. 2009. Historical fire and multidecadal drought as context for piñon–juniper woodland restoration in western Colorado. Ecological Applications. 19(5): 1231-1245. doi:10.1890/08-0846.1

Shinneman, D.J.; Means, R.E.; Potter, K.M.; Hipkins, V.D. 2016. Exploring climate niches of ponderosa pine (*Pinus ponderosa* Douglas ex Lawson) haplotypes in the western United States: Implications for evolutionary history and conservation. PLoS ONE. 11(3): e0151811 (24 p). doi:10.1371/journal.pone.0151811

Shirley, D.M.; Erickson, V. 2001. Aspen restoration in the Blue Mountains of northeast Oregon. In: Shepperd, W.D.; Binkley, D.; Bartos, D.L.; Stohlgren, T.J.; Eskew, L.G., comps. Sustaining aspen in western landscapes: symposium proceedings. Proceedings RMRS-P-18. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 101-115. https://www.fs.usda.gov/treesearch/pubs/35810

Shive, K.L.; Fulé, P.Z.; Sieg, C.H.; Strom, B.A.; Hunter, M.E. 2014. Managing burned landscapes: evaluating future management strategies for resilient forests under a warming climate. International Journal of Wildland Fire. 23(7): 915-928. doi:10.1071/WF13184

Shive, K.L.; Preisler, H.K.; Welch, K.R.; Safford, H.D.; Butz, R.J.; O'Hara, Kevin L.; Stephens, S.L. 2018. From the stand scale to the landscape scale: predicting the spatial patterns of forest regeneration after disturbance. Ecological Applications. 28(6): 1626-1639. doi:10.1002/eap.1756

Shlisky, A.J. 1994. Multiscale analysis in the Pacific Northwest. Journal of Forestry. 92(8): 32-34. doi:10.1093/jof/92.8.32

Show, S.B.; Kotok, E.I. 1924. The role of fire in the California pine forests. Bull. No. 1294. Washington, DC: U.S. Department of Agriculture. 80 p. Pamphlets on Forestry in California

Shreve, F. 1917. The density of stand and rate of growth of Arizona yellow pine as influenced by climatic conditions. Journal of Forestry. 15(6): 695-707. doi:10.1093/jof/15.6.695

Sieg, C.H.; McMillin, J.D.; Fowler, J.F.; Allen, K.K.; Negron, J.F.; Wadleigh, L.L.; Anhold, J.A.; Gibson, K.E. 2006. Best predictors for postfire mortality of ponderosa pine trees in the Intermountain West. Forest Science. 52(6): 718-728. doi:10.1093/forestscience/52.6.718

Siegel, R.B.; DeSante, D.F. 2003. Bird communities in thinned versus unthinned Sierran mixed conifer stands. Wilson Bulletin. 115(2): 155-165. doi:10.1676/02-103

Simard, S.W. 2009. The foundational role of mycorrhizal networks in self-organization of interior Douglas-fir forests. Forest Ecology and Management. 258(Supplement): S95-S107. doi:10.1016/j.foreco.2009.05.001

Simpson, W.T. 2004. Effect of drying temperature on warp and downgrade of 2 by 4's from small-diameter ponderosa pine. Res. Paper FPL-RP-624. Madison, WI: USDA Forest Service, Forest Products Laboratory. 8 p. https://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp624.pdf

Simpson, W.T.; Wang, X.; Verrill, S. 2003. Heat sterilization time of ponderosa pine and Douglas-fir boards and square timbers. Res. Paper FPL-RP-607. Madison, WI: USDA Forest Service, Forest Products Laboratory. 24 p. https://www.fs.usda.gov/treesearch/pubs/7546

Singer, J.A.; Turnbull, R.; Foster, M.; Bettigole, C.; Frey, B.R.; Downey, M.C.; Covey, K.R.; Ashton, M.S. 2019. Sudden aspen decline: A review of pattern and process in a changing climate. Forests. 10(8): 671 (17 p). doi:10.3390/f10080671

Singleton, M.P.; Thode, A.E.; Sánchez Meador, A.J.; Iniguez, J.M. 2019. Increasing trends in high-severity fire in the southwestern USA from 1984 to 2015. Forest Ecology and Management. 433: 709-719. doi:10.1016/j.foreco.2018.11.039

Skinner, D. 2006. Ring of fire. Evergreen(mid-spring): 4-15.

Skog, K.E.; Barbour, R.J. 2006. Estimating woody biomass supply from thinning treatments to reduce fire hazard in the U.S. West. In: Andrews, P.L.; Butler, B.W., comps. Fuels management—how to measure success: Conference proceedings. Proceedings RMRS-P-41. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 657-672. https://www.fs.usda.gov/treesearch/pubs/25986

Skog, K.E.; Barbour, R.J.; Abt, K.L.; Bilek, E.M.T.; Burch, F.; Fight, R.D.; Hugget, R.J.; Miles, P.D.; Reinhardt, E.D.; Sheppard, W.D. 2006. Evaluation of silvicultural treatments and biomass use for reducing fire hazard in western states. Res. Paper FPL-RP-634. Madison, WI: USDA Forest Service, Forest Products Laboratory. 29 p. https://www.fs.usda.gov/treesearch/pubs/24554

Skov, K.R.; Kolb, T.E.; Wallin, K.F. 2004. Tree size and drought affect ponderosa pine physiological response to thinning and burning treatments. Forest Science. 50(1): 81-91. doi:10.1093/forestscience/50.1.81

Skov, K.R.; Kolb, T.E.; Wallin, K.F. 2005. Difference in radial growth response to restoration thinning and burning treatments between young and old ponderosa pine in Arizona. Western Journal of Applied Forestry. 20(1): 36-43. doi:10.1093/wjaf/20.1.36

Skovlin, J.M.; Thomas, J.W. 1995. Interpreting long-term trends in Blue Mountain ecosystems from repeat photography. Res. Pap. PNW-GTR-315. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 102 p. http://www.treesearch.fs.fed.us/pubs/25667

Skovlin, J.M.; Harris, R.W.; Strickler, G.S.; Garrison, G.A. 1976. Effects of cattle grazing methods on ponderosa pine-bunchgrass range in the Pacific Northwest. Tech. Bull. No. 1531. Washington, DC: USDA Forest Service. 40 p. http://ageconsearch.umn.edu/record/158102/files/CAT76674950PDF.pdf

Skovlin, J.M.; Strickler, G.S.; Peterson, J.L.; Sampson, A.W. 2001. Interpreting landscape change in high mountains of northeastern Oregon from long-term repeat photography. Gen. Tech. Rep. PNW-GTR-505. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 78 p. http://www.treesearch.fs.fed.us/pubs/3079

Shunk, S.A. 2011. Meriwether Lewis woud be proud: helping Lewis's namesake woodpecker in the pine forests of Oregon. Living Bird Magazine. Winter: 32-37. http://www.allaboutbirds.org/Page.aspx?pid=2141

Sloan, J.P. 1998a. Historical density and stand structure of an old-growth forest in the Boise basin of central Idaho. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL: Tall Timbers Research Station: 258-266. https://talltimbers.org/wp-content/uploads/2018/09/258-Sloan1998a_op.pdf

Sloan, J.P. 1998b. Interruption of the natural fire cycle in a grand fir forest of central Idaho: changes in stand structure and composition. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL: Tall Timbers Research Station: 250-257. https://talltimbers.org/wp-content/uploads/2018/09/250-Sloan1998_op.pdf

Sloan, J.P.; Ryker, R.A. 1986. Large scalps improve survival and growth of planted conifers in central Idaho. Res. Pap. INT-366. Ogden, UT: USDA Forest Service, Intermountain Research Station. 9 p. https://archive.org/download/largescalpsimpro366sloa/largescalpsimpro366sloa.pdf

Sloan, J.P.; Jump, L.H.; Ryker, R.A. 1987. Container-grown ponderosa pine seedlings outperform bareroot seedlings on harsh sites in southern Utah. Ogden, UT: USDA Forest Service, Intermountain Research Station. 14 p. https://archive.org/download/containergrownpo384sloa/containergrownpo384sloa.pdf

Smith, R.E.K. 1912. Report of the present condition of insect infestation on the Whitman National Forest, Oregon. Unpublished typescript report obtained from National Archives, College Park, MD; record group 95. 13 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5414279.pdf

Smith, D.R. 1967. Effects of cattle grazing on a ponderosa pine-bunchgrass range in Colorado. Tech. Bulletin No. 1371. Washington, DC: USDA Forest Service. 60 p. https://www.fs.usda.gov/treesearch/pubs/59385

Smith, G.W. 1982. Habitat use by porcupines in a ponderosa pine/Douglas-fir forest in northeastern Oregon. Northwest Science. 56(3): 236-240.

Smith, J.K., ed. 2000. Wildland fire in ecosystems: effects of fire on fauna. Gen. Tech. Rep. RMRS-GTR-42-volume 1. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 83 p. http://www.treesearch.fs.fed.us/pubs/4553

Smith, H.Y.; Arno, S.F. 1999. Eighty-eight years of change in a managed ponderosa pine forest. Gen. Tech. Rep. RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 55 p. https://www.fs.usda.gov/treesearch/pubs/28424

Smith, J.K.; Fischer, W.C. 1997. Fire ecology of the forest habitat types of northern Idaho. Gen. Tech. Rep. INT-GTR-363. Ogden, UT: USDA Forest Service, Intermountain Research Station. 142 p. http://www.treesearch.fs.fed.us/pubs/34304

Smith, T.; Huston, M. 1989. A theory of the spatial and temporal dynamics of plant communities. Vegetatio. 83(1/2): 49-69. doi:10.1007/BF00031680

Smith, R.C.; Kurtz, W.B.; Johnson, T.E. 1988. Cost efficiency of pruning Black Hills ponderosa pine. Western Journal of Applied Forestry. 3(1): 10-14. doi:10.1093/wjaf/3.1.10

Smith, D.M.; Larson, B.C.; Kelty, M.J.; Ashton, P.M.S. 1997. The practice of silviculture: applied forest ecology. 9th edition. New York: John Wiley & Sons. 537 p. isbn:0-471-10941-X

Smith, J.E.; McKay, D.; Niwa, C.G.; Thies, W.G.; Brenner, G.; Spatafora, J.W. 2004. Short-term effects of seasonal prescribed burning on the ectomycorrhizal fungal community and fine root biomass in ponderosa pine stands in the Blue Mountains of Oregon. Canadian Journal of Forest Research. 34(12): 2477-2491. doi:10.1139/x04-124

Smith, J.E.; Kluber, L.A.; Jennings, T.N.; McKay, D.; Brenner, G.; Sulzman, E.W. 2017. Does the presence of large down wood at the time of a forest fire impact soil recovery? Forest Ecology and Management. 391(Supplement C): 52-62. doi:10.1016/j.foreco.2017.02.013

Smith, R.J.; Gray, A.N.; Swanson, M.E. 2020. Peak plant diversity during early forest development in the western United States. Forest Ecology and Management. 475: 118410 (11 p). doi:10.1016/j.foreco.2020.118410

Snider, G.; Daugherty, P.J.; Wood, D. 2006. The irrationality of continued fire suppression: An avoided cost analysis of fire hazard reduction treatments versus no treatment. Journal of Forestry. 104(8): 431-437. doi:10.1093/jof/104.8.431

Society of American Foresters. 1981. Choices in silviculture for American forests. Washington, DC: Society of American Foresters. 80 p. isbn:0-939970-09-0

Soeriaatmadja, R.E. 1966. Fire history of the ponderosa pine forests of the Warm Springs Indian Reservation, Oregon. Ph.D. dissertation. [Corvallis, OR]: Oregon State University. 123 p. https://ir.library.oregonstate.edu/downloads/c821gm924?locale=en

Sohi, S.P.; Krull, E.; Lopez-Capel, E.; Bol, R. 2010. A review of biochar and its use and function in soil. Advances in Agronomy. 105: 47-82. doi:10.1016/S0065-2113(10)05002-9

Sohn, J.A.; Saha, S.; Bauhus, J. 2016. Potential of forest thinning to mitigate drought stress: A meta-analysis. Forest Ecology and Management. 380: 261-273. doi:10.1016/j.foreco.2016.07.046

Sorensen, F.C.; Weber, J.C. 1994. Genetic variation and seed transfer guidelines for ponderosa pine in the Ochoco and Malheur national forests. Res. Pap. PNW-RP-468. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 30 p. https://www.fs.usda.gov/treesearch/pubs/20581

Sorensen, C.D.; Finkral, A.J.; Kolb, T.E.; Huang, C.H. 2011. Short- and long-term effects of thinning and prescribed fire on carbon stocks in ponderosa pine stands in northern Arizona. Forest Ecology and Management. 261(3): 460-472. doi:10.1016/j.foreco.2010.10.031

Soulé, P.T.; Knapp, P.A. 2006. Radial growth rate increases in naturally occurring ponderosa pine trees: a late-20th century CO_2 fertilization effect? New Phytologist. 171(2): 379-390. doi:10.1111/j.1469-8137.2006.01746.x

Souto, X.C.; Chiapusio, G.; Pellissier, F. 2000. Relationships between phenolics and soil microorganisms in spruce forests: significance for natural regeneration. Journal of Chemical Ecology. 26(9): 2025-2034. doi:10.1023/A:1005504029243

Spada, B. 1960. Estimating past diameters of several species in the ponderosa pine subregion of Oregon and Washington. Research Note No. 181. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 4 p. https://www.fs.usda.gov/treesearch/pubs/25833

Sparhawk, W.N. 1918. Effect of grazing upon western yellow pine reproduction in central Idaho.

Bull. No. 738. Washington, DC: U.S. Department of Agriculture. 31 p. https://www.archive.org/download/effectofgrazingu738spar/effectofgrazingu738spar.pdf

Spies, T. 1997. Forest stand structure, composition, and function. In: Kohm, K.A.; Franklin, J.F., eds. Creating a forestry for the 21st century: the science of ecosystem management. Washington, DC: Island Press: 11-30. isbn:1-55963-399-9

Spies, T.A.; Tappeiner, J.; Pojar, J.; Coates, D. 1991. Trends in ecosystem management at the stand level. In: Transactions of the 56th North American wildlife and natural resources conference. Washington, DC: Wildlife Management Institute: 628-639. http://andrewsforest.oregonstate.edu/pubs/pdf/pub1280.pdf

Spies, T.; Giesen, T.; Swanson, F.; Franklin, J.; Lach, D.; Johnson, K. 2010. Climate change adaptation strategies for federal forests of the Pacific Northwest, USA: ecological, policy, and socio-economic perspectives. Landscape Ecology. 25(8): 1185-1199. doi:10.1007/s10980-010-9483-0

Spies, T.A.; White, E.; Ager, A.; Kline, J.D.; Bolte, J.P.; Platt, E.K.; Olsen, K.A.; Pabst, R.J.; Barros, A.M.G.; Bailey, J.D.; Charnley, S.; Morzillo, A.T.; Koch, J.; Steen-Adams, M.M.; Singleton, P.H.; Sulzman, J.; Schwartz, C.; Csuti, B. 2017. Using an agent-based model to examine forest management outcomes in a fire-prone landscape in Oregon, USA. Ecology and Society. 22(1): 25 (55 p). doi:10.5751/ES-08841-220125

Spracklen, D.V.; Logan, J.A.; Mickley, L.J.; Park, R.J.; Yevich, R.; Westerling, A.L.; Jaffe, D.A. 2007. Wildfires drive interannual variability of organic carbon aerosol in the western U.S. in summer. Geophysical Research Letters. 34: L16816 (4 p). doi:10.1029/2007GL030037

Springer, J.D.; Huffman, D.W.; Stoddard, M.T.; Sánchez Meador, A.J.; Waltz, A.E.M. 2018. Plant community dynamics following hazardous fuel treatments and mega-wildfire in a warm-dry mixed-conifer forest of the USA. Forest Ecology and Management. 429: 278-286. doi:10.1016/j.foreco.2018.06.022

Sproat, W.J. 1930. Natural reproduction of western yellow pine. Journal of Forestry. 28(3): 334-337. doi:10.1093/jof/28.3.334

Squillace, A.E.; Silen, R.R. 1962. Racial variation in ponderosa pine. Forest Science. 8(Forest Science Monograph 2): 27 p. doi:10.1093/forestscience/8.s1.a0001

St. George, R.A. 1930. Drought-affected and injured trees attractive to bark beetles. Journal of Economic Entomology. 23(5): 825-828. doi:10.1093/jee/23.5.825

St. John, A.D. 2007. Oregon's dry side: exploring east of the Cascade crest. Portland, OR: Timber Press. 323 p. isbn:978-0-88192-829-7

Stallcup, P.L. 1968. Spatio-temporal relationships of nuthatches and woodpeckers in ponderosa pine forests of Colorado. Ecology. 49(5): 831-843. doi:10.2307/1936534

Stan, A.B.; Fulé, P.Z.; Ireland, K.B.; Sanderlin, J.S. 2014. Modern fire regime resembles historical fire regime in a ponderosa pine forest on Native American lands. International Journal of Wildland Fire. 23(5): 686-697. doi:10.1071/WF13089

Stanton, S. 2006. The differential effects of dwarf mistletoe infection and broom abundance on the radial growth of managed ponderosa pine. Forest Ecology and Management. 223(1-3): 318-326. doi:10.1016/j.foreco.2005.11.011

Stanton, S. 2007. Effects of dwarf mistletoe on climate response of mature ponderosa pine trees. Tree-Ring Research. 63(2): 69-80. doi:10.3959/1536-1098-63.2.69

Stanton, S.; Arabas, K.B. 2009. Fuel and stand conditions in an isolated, unmanaged forest landscape in central Oregon. Annals of Forest Science. 66(2): art207 (10 p). doi:10.1051/forest/2008089

Stanton, S.; Hadley, K.S. 2010. Influence of western dwarf mistletoe (Arceuthobium campylopodum Engelm.) on surface fuels and snag abundance in mature ponderosa pine and mixed conifer stands in central Oregon. Natural Areas Journal. 30(3): 261-270. doi:10.3375/043.030.0302

Starker, T.J. 1915. Recommendations for cutting inferior species on the Whitman National Forest, Oregon. Unpublished report obtained from National Archives, College Park, Maryland; record group 95. 10 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5414184.pdf

Starker, T.J. 1934. Fire resistance in the forest. Journal of Forestry. 32(4): 462-467. doi:10.1093/jof/32.4.462

Starns, H.D.; Fuhlendorf, S.D.; Elmore, R.D.; Twidwell, D.; Thacker, E.T.; Hovick, T.J.; Luttbeg, B. 2019. Recoupling fire and grazing reduces wildland fuel loads on rangelands. Ecosphere. 10(1): e02578 (15 p). doi:10.1002/ecs2.2578

Steel, Z.L.; Koontz, M.J.; Safford, H.D. 2018. The changing landscape of wildfire: burn pattern trends and implications for California's yellow pine and mixed conifer forests. Landscape Ecology. 33(7): 1159-1176. doi:10.1007/s10980-018-0665-5

Steele, R. 1994. The role of succession in forest health. Journal of Sustainable Forestry. 2(1-2): 183-190. doi:10.1300/J091v02n01_08

Steele, R.; Geier-Hayes, K. 1995. Major Douglas-fir habitat types of central Idaho: a summary of succession and management. Gen. Tech. Rep. INT-GTR-331. Ogden, UT: USDA Forest Service, Intermountain Research Station. 23 p. https://archive.org/download/CAT10744994/CAT10744994.pdf

Steele, R.; Arno, S.F.; Geier-Hayes, K. 1986. Wildfire patterns change in central Idaho's ponderosa pine–Douglas-fir forest. Western Journal of Applied Forestry. 1(1): 16-18. doi:10.1093/wjaf/1.1.16

Steele, R.; Williams, R.E.; Weatherby, J.C.; Reinhardt, E.D.; Hoffman, J.T.; Thier, R.W. 1996. Stand hazard rating for central Idaho forests. Gen. Tech. Rep. INT-GTR-332. Ogden, UT: USDA Forest Service, Intermountain Research Station. 29 p. https://www.fs.usda.gov/treesearch/pubs/23915

Steele, B.M.; Reddy, S.K.; Keane, R.E. 2006. A methodology for assessing departure of current plant communities from historical conditions over large landscapes. Ecological Modelling. 199(1): 53-63. doi:10.1016/j.ecolmodel.2006.06.016

Stein, S.J. 1988. Explanations of the imbalanced age structure and scattered distribution of ponderosa pine within a high-elevation mixed coniferous forest. Forest Ecology and Management. 25(2): 139-153. doi:10.1016/0378-1127(88)90125-9

Stein, S.J.; Kimberling, D.N. 2003. Germination, establishment, and mortality of naturally seeded southwestern ponderosa pine. Western Journal of Applied Forestry. 18(2): 109-114. doi:10.1093/wjaf/18.2.109

Steinhoff, R.J. 1970. Northern Idaho ponderosa pine racial variation study--50-year results. Res. Note INT-118. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 4 p. https://archive.org/download/northernidahopon118stei/northernidahopon118stei.pdf

Steinberg, P.D. 2002. *Pseudotsuga menziesii* var. *glauca*. In: Fire Effects Information System [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). https://www.fs.fed.us /database/feis/plants/tree/psemeng/all.html

Steinhoff, R.J. 1970. Northern Idaho ponderosa pine racial variation study--50-year results. Res. Note INT-118. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 4 p. https://archive.org/download/northernidahopon118stei/northernidahopon118stei.pdf

Stephens, S.L. 1998. Evaluation of the effects of silvicultural and fuels treatments on potential fire behaviour in Sierra Nevada mixed-conifer forests. Forest Ecology and Management. 105(1-3): 21-35. doi:10.1016/S0378-1127(97)00293-4

Stephens, S.L.; Finney, M.A. 2002. Prescribed fire mortality of Sierra Nevada mixed conifer tree species: Effects of crown damage and forest floor consumption. Forest Ecology and Management. 162(2-3): 261-271. doi:10.1016/S0378-1127(01)00521-7

Stephens, S.L.; Moghaddas, J.J. 2005. Fuel treatment effects on snags and coarse woody debris in a Sierra Nevada mixed conifer forest. Forest Ecology and Management. 214(1-3): 53-64. doi:10.1016/j.foreco.2005.03.055

Stephens, S.L.; Ruth, L.W. 2005. Federal forest-fire policy in the United States. Ecological Applications. 15(2): 532-542. doi:10.1890/04-0545

Stephens, S.S.; Wagner, M.R. 2006. Using ground foraging ant (Hymenoptera: Formicidae) functional groups as bioindicators of forest health in northern Arizona ponderosa pine forests. Environmental Entomology. 35(4): 937-949. doi:10.1603/0046-225X-35.4.937

Stephens, S.L.; Martin, R.E.; Clinton, N.E. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. Forest Ecology and Management. 251(3): 205-216. doi:10.1016/j.foreco.2007.06.005

Stephens, S.L.; Moghaddas, J.J.; Edminster, C.; Fiedler, C.E.; Haase, S.; Harrington, M.; Keeley, J.E.; Knapp, E.E.; McIver, J.D.; Metlen, K.; Skinner, C.N.; Youngblood, A. 2009. Fire treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. Ecological Applications. 19(2): 305-320. doi:10.1890/07-1755.1

Stephens, S.L.; Millar, C.I.; Collins, B.M. 2010. Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates. Environmental Research Letters. 5(2): 024003 (9 p.). doi:10.1088/1748-9326/5/2/024003

Stephens, S.L.; Collins, B.M.; Roller, G. 2012a. Fuel treatment longevity in a Sierra Nevada mixed conifer forest. Forest Ecology and Management. 285: 204-212. doi:10.1016/j.foreco.2012.08.030

Stephens, S.L.; McIver, J.D.; Boerner, R.E.J.; Fettig, C.J.; Fontaine, J.B.; Hartsough, B.R.; Kennedy, P.L.; Schwilk, D.W. 2012b. The effects of forest fuel-reduction treatments in the United States. BioScience. 62(6): 549-560. doi:10.1525/bio.2012.62.6.6

Stephens, S.L.; Agee, J.K.; Fulé, P.Z.; North, M.P.; Romme, W.H.; Swetnam, T.W.; Turner, M.G. 2013. Managing forests and fire in changing climates. Science. 342(6154): 41-42. doi:10.1126/science.1240294

Stephens, S.L.; Burrows, N.; Buyantuyev, A.; Gray, R.W.; Keane, R.E.; Kubian, R.; Liu, S.; Seijo, F.; Shu, L.; Tolhurst, K.G.; van Wagtendonk, J.W. 2014. Temperate and boreal forest megafires: characteristics and challenges. Frontiers in Ecology and the Environment. 12(2): 115-122. doi:10.1890/120332

Stephens, S.L.; Lydersen, J.M.; Collins, B.M.; Fry, D.L.; Meyer, M.D. 2015. Historical and current landscape-scale ponderosa pine and mixed conifer forest structure in the Southern Sierra Nevada. Ecosphere. 6(5): art79 (63 p). doi:10.1890/es14-00379.1

Stephens, S.L.; Collins, B.M.; Biber, E.; Fulé, P.Z. 2016. U.S. federal fire and forest policy: emphasizing resilience in dry forests. Ecosphere. 7(11): e01584 (19 p). doi:10.1002/ecs2.1584

Stephens, S.L.; Collins, B.M.; Fettig, C.J.; Finney, M.A.; Hoffman, C.M.; Knapp, E.E.; North, M.P.; Safford, H.; Wayman, R.B. 2018. Drought, tree mortality, and wildfire in forests adapted to frequent fire. BioScience. 68(2): 77-88. doi:10.1093/biosci/bix146

Stephens, S.L.; Kobziar, L.N.; Collins, B.M.; Davis, R.; Fulé, P.Z.; Gaines, W.; Ganey, J.; Guldin, J.M.; Hessburg, P.F.; Hiers, K.; Hoagland, S.; Keane, J.J.; Masters, R.E.; McKellar, A.E.; Montague, W.; North, M.; Spies, T.A. 2019. Is fire "for the birds"? How two rare species influence fire management across the US. Frontiers in Ecology and the Environment. 17(7): 391-399. doi:10.1002/fee.2076

Stephens, S.L.; Westerling, A.L.; Hurteau, M.D.; Peery, M.Z.; Schultz, C.A.; Thompson, S. 2020. Fire and climate change: conserving seasonally dry forests is still possible. Frontiers in Ecology and the Environment. 18(6): 354-360. doi:10.1002/fee.2218

Stephenson, N.L. 1999. Reference conditions for giant sequoia forest restoration: structure, process, and precision. Ecological Applications. 9(4): 1253-1265. doi:10.1890/1051-0761(1999)009[1253:RCFGSF]2.0.CO;2

Stevens, W.K. 1990. New eye on nature: the real constant is eternal turmoil. New York: New York Times, Science Column for Tuesday, July 31, 1990. 2 p. new-eye-on-nature-the-real-constant-is-eternal-turmoil

Stevens, W.K. 1993. An Eden in ancient America? Not really. New York: New York Times, Science Column for Tuesday, March 30, 1993. 2 p. https://www.nytimes.com/1993/03/30/science/an-eden-in-ancient-america-not-really.html

Stevens, R.E.; Jennings, D.T. 1977. Western pine-shoot borer: a threat to intensive management of ponderosa pine in the Rocky Mountain area and southwest. Gen. Tech. Rep. RM-45. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p. Western_Pine_shoot_Borer

Stevens, R.E.; Brewer, J.W.; Leatherman, D.A. 1982. Insects associated with ponderosa pine in the Rocky Mountains and the southwest. Gen. Tech. Rep. RM-94. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 44 p. https://archive.org/download/CAT83787337/CAT83787337.pdf

Stevens, J.T.; Collins, B.M.; Miller, J.D.; North, M.P.; Stephens, S.L. 2017. Changing spatial patterns of stand-replacing fire in California conifer forests. Forest Ecology and Management. 406: 28-36. doi:10.1016/j.foreco.2017.08.051

Stevenson, G.E. 1937. Sale prospectus and timber appraisal report; Camas Creek Unit. Unpublished typescript report. [Place of publication unknown]: USDA Forest Service, Umatilla National Forest. 23 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015566.pdf

Stevens-Rumann, C.; Shive, K.; Fulé, P.; Sieg, C.H. 2013. Pre-wildfire fuel reduction treatments result in more resilient forest structure a decade after wildfire. International Journal of Wildland Fire. 22(8): 1108-1117. doi:10.1071/WF12216

Stevens-Rumann, C.S.; Kemp, K.B.; Higuera, P.E.; Harvey, B.J.; Rother, M.T.; Donato, D.C.; Morgan, P.; Veblen, T.T. 2018. Evidence for declining forest resilience to wildfires under climate change. Ecology Letters. 21(2): 243-252. doi:10.1111/ele.12889

Stewart, O.C. 1951. Burning and natural vegetation in the United States. Geographical Review. 41(2): 317-320. http://www.jstor.org/stable/211026

Stewart, O.C. 2009. Forgotten fires: Native Americans and the transient wilderness. Norman, OK: University of Oklahoma Press. 364 p. isbn:978-0-8061-4037-7

Stewart, R.E.; Beebe, T. 1974. Survival of ponderosa pine seedlings following control of competing grasses. In: 1974 Proceedings of the Western Society of Weed Science; volume 27: 55-58. 1974%20Proceedings%20Western%20Society%20of%20Weed%20Science

Stewart, I.T.; Cayan, D.R.; Dettinger, M.D. 2004. Changes in snowmelt runoff timing in western North America under a 'business as usual' climate change scenario. Climatic Change. 62(1): 217-232. doi:10.1023/B:CLIM.0000013702.22656.e8

Stidham, M.; Simon-Brown, V. 2011. Stakeholder perspectives on converting forest biomass to energy in Oregon, USA. Biomass and Bioenergy. 35(1): 203-213. doi:10.1016/j.biombioe.2010.08.014

Stine, P.; Hessburg, P.; Spies, T.; Kramer, M.; Fettig, C.J.; Hansen, A.; Lehmkuhl, J.; O'Hara, K.; Polivka, K.; Singleton, P.; Charnley, S.; Merschel, A.; White, R. 2014. The ecology and management of moist mixed-conifer forests in eastern Oregon and Washington: A synthesis of the relevant biophysical science and implications for future land management. Gen. Tech. Rep. PNW-GTR-897. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 254 p. http://www.treesearch.fs.fed.us/pubs/47086

St. John, T.V.; Rundel, P.W. 1976. The role of fire as a mineralizing agent in a Sierran coniferous forest. Oecologia. 25(1): 35-45. www.jstor.org/stable/4215301

Stockdale, C.A.; McLoughlin, N.; Flannigan, M.; Macdonald, S.E. 2019. Could restoration of a landscape to a pre-European historical vegetation condition reduce burn probability? Ecosphere. 10(2): e02584 (18 p). doi:10.1002/ecs2.2584

Stoddard, H.L. 1931. The bobwhite quail: its habits, preservation, and increase. New York: Charles Scribner's Sons. 559 p.

Stoddard, M.T.; Sánchez Meador, A.J.; Fulé, P.Z.; Korb, J.E. 2015. Five-year post-restoration conditions and simulated climate-change trajectories in a warm/dry mixed-conifer forest, southwestern Colorado, USA. Forest Ecology and Management. 356: 253-261. doi:10.1016/j.foreco.2015.07.007

Stone, E.C.; Schubert, G.H. 1959. The physiological condition of ponderosa pine (Pinus ponderosa Laws.) planting stock as it affects survival after cold storage. Journal of Forestry. 57(11): 837-841. doi:10.1093/jof/57.11.837

Stone, J.E.; Kolb, T.E.; Covington, W.W. 1999. Effects of restoration thinning on presettlement *Pinus ponderosa* in northern Arizona. Restoration Ecology. 7(2): 172-182. doi:10.1046/j.1526-100X.1999.72009.x

Stone, K.; Pilliod, D.; Dwire, K.; Rhoades, C.; Wollrab, S.; Young, M. 2010. Fuel reduction management practices in riparian areas of the western USA. Environmental Management. 46(1): 91-100. doi:10.1007/s00267-010-9501-7

Storck, P.; Kern, T.; Bolton, S. 1999. Measurement of differences in snow accumulation, melt, and micrometeorology due to forest harvesting. Northwest Science. 73(Special Issue): 87-101. http://hdl.handle.net/2376/1172

Storm, G.L.; Halvorson, C.H. 1967. Effect of injury by porcupines on radial growth of ponderosa pine. Journal of Forestry. 65(10): 740-743. doi:10.1093/jof/65.10.740

Stoszek, K.J. 1973. Damage to ponderosa pine plantations by the western pine-shoot borer. Journal of Forestry. 71(11): 701-705. doi:10.1093/jof/71.11.701

Stoszek, K.J. 1988. Forests under stress and insect outbreaks. Northwest Environmental Journal. 4: 247-261.

Stout, D.L.; Sala, A. 2003. Xylem vulnerability to cavitation in *Pseudotsuga menziesii* and *Pinus ponderosa* from contrasting habitats. Tree Physiology. 23(1): 43-50. doi:10.1093/treephys/23.1.43

Strahan, R.T.; Stoddard, M.T.; Springer, J.D.; Huffman, D.W. 2015. Increasing weight of evidence that thinning and burning treatments help restore understory plant communities in ponderosa pine forests. Forest Ecology and Management. 353: 208-220. doi:10.1016/j.foreco.2015.05.040

Strickler, G.S.; Edgerton, P.J. 1976. Emergent seedlings from coniferous litter and soil in eastern Oregon. Ecology. 57(4): 801-807. doi:10.2307/1936193

Strom, B.A.; Fulé, P.Z. 2007. Pre-wildfire fuel treatments affect long-term ponderosa pine forest dynamics. International Journal of Wildland Fire. 16(1): 128-138. doi:10.1071/WF06051

Strunk, J.L.; Harrington, C.A.; Brodie, L.C.; Prevéy, J.S. 2020. Seeing the forest below the trees: occurrences of shrubs in the Pacific Northwest. Gen. Tech. Rep. PNW-GTR-980. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 87 p. https://www.fs.usda.gov/treesearch/pubs/59327

Strzepek, K.; Yohe, G.; Neumann, J.; Boehlert, B. 2010. Characterizing changes in drought risk for the United States from climate change. Environmental Research Letters. 5(4): 044012 (9 p.). doi:10.1088/1748-9326/5/4/044012

Stuart, J.D.; Agee, J.K.; Gara, R.I. 1989. Lodgepole pine regeneration in an old, self-perpetuating forest in south-central Oregon. Canadian Journal of Forest Research. 19(9): 1096-1104. doi:10.1139/x89-166

Sturgeon, K.B. 1979. Monoterpene variation in ponderosa pine xylem resin related to western pine beetle predation. Evolution. 33(3): 803-814. doi:10.1111/j.1558-5646.1979.tb04736.x

Sullivan, T.P.; Sullivan, D.S.; Lindgren, P.M.F. 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecological Applications. 11(4): 1151-1173. doi:10.1890/1051-0761(2001)011[1151:SSASMI]2.0.CO;2

Sun, S.; Sun, G.; Caldwell, P.; McNulty, S.; Cohen, E.; Xiao, J.; Zhang, Y. 2015. Drought impacts on ecosystem functions of the U.S. National Forests and Grasslands: Part II assessment results and management implications. Forest Ecology and Management. 353: 269-279. doi:10.1016/j.foreco.2015.04.002

Sutherland, E.K.; Covington, W.W.; Andariese, S. 1991. A model of ponderosa pine growth response to prescribed burning. Forest Ecology and Management. 44(2-4): 161-173. doi:10.1016/0378-1127(91)90005-G

Swanson, D.K.; Schmitt, C.L.; Shirley, D.M.; Erickson, V.; Schuetz, K.J.; Tatum, M.L.; Powell, D.C. 2010. Aspen biology, community classification, and management in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-806. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 117 p. http://www.treesearch.fs.fed.us/pubs/35257

Swanson, M.E.; Franklin, J.F.; Beschta, R.L.; Crisafulli, C.M.; DellaSala, D.A.; Hutto, R.L.; Lindenmayer, D.B.; Swanson, F.J. 2011. The forgotten stage of forest succession: early-successional ecosystems on forest sites. Frontiers in Ecology and the Environment. 9(2): 117-125. doi:10.1890/090157

Swetnam, T.W. 1984. Peeled ponderosa pine trees: a record of inner bark utilization by Native Americans. Journal of Ethnobiology. 4(2): 177-190. https://ethnobiology.org/sites/default/files/pdfs/JoE/4-2/Swetnam1984.pdf

Swetnam, T.W.; Allen, C.D.; Betancourt, J.L. 1999. Applied historical ecology: using the past to manage for the future. Ecological Applications. 9(4): 1189-1206. doi:10.1890/1051-0761(1999)009[1189:AHEUTP]2.0.CO;2

Swezy, D.M.; Agee, J.K. 1991. Prescribed-fire effects on fine-root and tree mortality in old-growth ponderosa pine. Canadian Journal of Forest Research. 21(5): 626-634. doi:10.1139/x91-086

Switzer, J.M.; Hope, G.D.; Grayston, S.J.; Prescott, C.E. 2012. Changes in soil chemical and biological properties after thinning and prescribed fire for ecosystem restoration in a Rocky Mountain Douglas-fir forest. Forest Ecology and Management. 275: 1-13. doi:10.1016/j.foreco.2012.02.025

Symstad, A.J.; Newton, W.E.; Swanson, D.J. 2014. Strategies for preventing invasive plant outbreaks after prescribed fire in ponderosa pine forest. Forest Ecology and Management. 324: 81-88. doi:10.1016/j.foreco.2014.04.022

Szaro, R.C.; Boyce, D.A.; Puchlerz, T. 2005. The challenges associated with developing science-based landscape scale management plans. Landscape and Urban Planning. 72(1): 3-12. doi:10.1016/j.landurbplan.2004.09.011

Tabacaru, C.A.; Erbilgin, N. 2015. Competitors and natural enemies may cumulatively mediate Dendroctonus ponderosae colonization of burned Pinus forests. Forest Ecology and Management. 337: 98-109. doi:10.1016/j.foreco.2014.10.026

Tabacaru, C.A.; McPike, S.M.; Erbilgin, N. 2015. Fire-mediated interactions between a tree-killing bark beetle and its competitors. Forest Ecology and Management. 356: 262-272. doi:10.1016/j.foreco.2015.07.006

Tanaka, J.A.; Starr, G.L.; Quigley, T.M. 1995. Strategies and recommendations for addressing forest health issues in the Blue Mountains of Oregon and Washington. Gen. Tech. Rep. PNW-GTR-350. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 18 p. http://www.treesearch.fs.fed.us/pubs/8970

Tappeiner, J.C.; Huffman, D.; Marshall, D.; Spies, T.A.; Bailey, J.D. 1997. Density, ages, and growth rates in old-growth and young-growth forests in coastal Oregon. Canadian Journal of Forest Research. 27(5): 638-648. doi:10.1139/x97-015

Tarrant, R.F. 1953. Soil moisture and the distribution of lodgepole and ponderosa pine: A review of the literature. Res. Paper No. 8. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 10 p. https://www.fs.usda.gov/treesearch/pubs/26028

Taylor, A.H. 2010. Fire disturbance and forest structure in an old-growth *Pinus ponderosa* forest, southern Cascades, USA. Journal of Vegetation Science. 21(3): 561-572. doi:10.1111/j.1654-1103.2009.01164.x

Taylor, A.H.; Beaty, R.M. 2005. Climatic influences on fire regimes in the northern Sierra Nevada mountains, Lake Tahoe Basin, Nevada, USA. Journal of Biogeography. 32(3): 425-438. doi:10.1111/j.1365-2699.2004.01208.x

Taylor, A.H.; Scholl, A.E. 2012. Climatic and human influences on fire regimes in mixed conifer forests in Yosemite National Park, USA. Forest Ecology and Management. 267: 144-156. doi:10.1016/j.foreco.2011.11.026

Taylor, S.W.; Sherman, K.L. 1996. Biomass consumption and smoke emissions from contemporary and prehistoric wildland fires in British Columbia. FRDA Report 249. Victoria, BC: Canadian Forest Service. 23 p. https://cfs.nrcan.gc.ca/pubwarehouse/pdfs/4330.pdf

Taylor, A.H.; Skinner, C.N. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management. 111(2-3): 285-301. doi:10.1016/S0378-1127(98)00342-9

Taylor, A.H.; Skinner, C.N. 2003. Spatial patterns and controls on historical fire regimes and forest structure in the Klamath Mountains. Ecological Applications. 13(3): 704-719. doi:10.1890/1051-0761(2003)013[0704:Spacoh]2.0.Co;2

Taylor, P.D.; Fahrig, L.; Henein, K.; Merriam, G. 1993. Connectivity is a vital element of landscape structure. Oikos. 68(3): 571-573. doi:10.2307/3544927

Tepley, A.J.; Hood, S.M.; Keyes, C.R.; Sala, A. 2020. Forest restoration treatments in a ponderosa pine forest enhance physiological activity and growth under climatic stress. Ecological Applications. 30(8): e02188 (18 p). doi:10.1002/eap.2188

Tesch, S.D.; Zuuring, H.R. 1983. Predicting young ponderosa pine growth in the Blackfoot River drainage, Montana. Northwest Science. 57(2): 91-96. http://hdl.handle.net/2376/1917

Thaxton, J.M.; Platt, W.J. 2006. Small-scale fuel variation alters fire intensity and shrub abundance in a pine savanna. Ecology. 87(5): 1331-1337. doi:10.1890/0012-9658(2006)87[1331:SFVAFI]2.0.CO;2

Thies, W.G.; Westlind, D.J. 2012. Validating the Malheur model for predicting ponderosa pine post-fire mortality using 24 fires in the Pacific Northwest, USA. International Journal of Wildland Fire. 21(5): 572-582. doi:10.1071/WF10091

Thies, W.G.; Westlind, D.J.; Loewen, M. 2005. Season of prescribed burn in ponderosa pine forests in eastern Oregon: impact on pine mortality. International Journal of Wildland Fire. 14(3): 223-231. doi:10.1071/WF04051

Thies, W.G.; Westlind, D.J.; Loewen, M.; Brenner, G. 2006. Prediction of delayed mortality of fire-damaged ponderosa pine following prescribed fires in eastern Oregon, USA. International Journal of Wildland Fire. 15(1): 19-29. doi:10.1071/WF05025

Thies, W.G.; Westlind, D.J.; Loewen, M.; Brenner, G. 2008. A field guide to predict delayed mortality of fire-damaged ponderosa pine: Application and validation of the Malheur model. Gen. Tech. Rep. PNW-GTR-769. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 16 p. http://www.treesearch.fs.fed.us/pubs/31092

Thies, W.G.; Westlind, D.J.; Loewen, M. 2013. Impact of spring or fall repeated prescribed fire on growth of ponderosa pine in eastern Oregon, USA. Western Journal of Applied Forestry. 28(3): 128-132. doi:10.5849/wjaf.11-044

Tholen, R.D. 1999. Modeling fire effects on stand composition and structure within riparian buffers in dry Douglas-fir/ponderosa pine forests. M.S. thesis. Moscow, ID: University of Idaho. 52 p.

Thomas, J.W. 1995. The Forest Service ethics and course to the future. Landscape and Urban Planning. 32(3): 157-159. doi:10.1016/0169-2046(94)00196-A

Thomas, J.W.; Anderson, R.G.; Maser, C.; Bull, E.L. 1979. Snags. In: Thomas, J.W., tech. ed. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. Agric. Handb. No. 553. Washington, DC: USDA Forest Service: 60-77. https://www.fs.usda.gov/treesearch/pubs/6630

Thompson, J. 2008. Fuel reduction and forest restoration treatments: once is not enough. Science Findings 106. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 5 p. https://www.fs.usda.gov/treesearch/pubs/30767

Thompson, G.; Johnson, A.J. 1900. Map of the state of Oregon showing the classification of lands and forests. Washington, DC: U.S. Depart. of the Interior, Geological Survey. 1:1,000,000; projection unknown; 29" × 23"; colored thematic map. https://pubs.usgs.gov/pp/0004/plate-1.pdf

Thompson, M.P.; Vaillant, N.M.; Haas, J.R.; Gebert, K.M.; Stockmann, K.D. 2013. Quantifying the potential impacts of fuel treatments on wildfire suppression costs. Journal of Forestry. 111(1): 49-58. doi:10.5849/jof.12-027

Thompson, M.P.; Bowden, P.; Brough, A.; Scott, J.H.; Gilbertson-Day, J.; Taylor, A.; Anderson, J.; Haas, J.R. 2016. Application of wildfire risk assessment results to wildfire response planning in the southern Sierra Nevada, California, USA. Forests. 7(3): 64 (23 p). doi:10.3390/f7030064

Thomson, W.G. 1940. A growth rate classification of southwestern ponderosa pine. Journal of Forestry. 38(7): 547-553. doi:10.1093/jof/38.7.547

Tiedemann, A.R. 1987. Combustion losses of sulfur from forest foliage and litter. Forest Science. 33(1): 216-223. doi:10.1093/forestscience/33.1.216

Tiedemann, A.R.; Klemmedson, J.O.; Bull, E.L. 2000. Solution of forest health problems with prescribed fire: Are forest productivity and wildlife at risk? Forest Ecology and Management. 127(1-3): 1-18. doi:10.1016/S0378-1127(99)00114-0

Tingley, M.W.; Ruiz-Gutiérrez, V.; Wilkerson, R.L.; Howell, C.A.; Siegel, R.B. 2016. Pyrodiversity promotes avian diversity over the decade following forest fire. Proceedings of the Royal Society B: Biological Sciences. 283(1840): 20161703 (9 p). doi:10.1098/rspb.2016.1703

Tinkham, W.T.; Dickinson, Y.; Hoffman, C.M.; Battaglia, M.A.; Ex, S.; Underhill, J. 2017. Visualization of heterogeneous forest structures following treatment in the southern Rocky Mountains. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 72 p. https://www.fs.usda.gov/treesearch/pubs/54887

Tinnin, R.O.; Kirkpatrick, L.A. 1985. The allelopathic influence of broadleaf trees and shrubs on seedlings of Douglas-fir. Forest Science. 31(4): 945-952. doi:10.1093/forestscience/31.4.945

Tisdale, E.W. 1961. Ecologic changes in the Palouse. Northwest Science. 35(4): 134-138.

Torgersen, T.R. 2001. Defoliators in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 11-20. http://hdl.handle.net/2376/976

Toumey, J.W. 1926. The vegetation of the forest floor; light versus soil moisture. Proceedings of International Congress of Plant Sciences. 1: 575-590.

Triepke, F.J.; Higgins, B.J.; Weisz, R.N.; Youtz, J.A.; Nicolet, T. 2011. Diameter caps and forest restoration: Evaluation of a 16-inch cut limit on achieving desired conditions. Forestry Rep. FR-R3-16-3. Albuquerque, NM: USDA Forest Service, Southwestern Region, Regional Office. 31 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5357567.pdf

Troendle, C.A. 1983. The potential for water yield augmentation from forest management in the Rocky Mountain region. Water Resources Bulletin. 19(3): 359-373. doi:10.1111/j.1752-1688.1983.tb04593.x

Tsamir, M.; Gottlieb, S.; Preisler, Y.; Rotenberg, E.; Tatarinov, F.; Yakir, D.; Tague, C.; Klein, T. 2019. Stand density effects on carbon and water fluxes in a semi-arid forest, from leaf to stand-scale. Forest Ecology and Management. 453: 117573 (13 p). doi:10.1016/j.foreco.2019.117573

Tubbesing, C.L.; Fry, D.L.; Roller, G.B.; Collins, B.M.; Fedorova, V.A.; Stephens, S.L.; Battles, J.J. 2019. Strategically placed landscape fuel treatments decrease fire severity and promote recovery in the northern Sierra Nevada. Forest Ecology and Management. 436: 45-55. doi:10.1016/j.foreco.2019.01.010

Tucker, G.J. 1940. History of the northern Blue Mountains. Unpub. Rep. [Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest.] 170 p. On file with: USDA Forest Service, Umatilla National Forest, Supervisor's Office, Pendleton, OR. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015563.pdf

Turner, H.C. 1918. The effect of planting method upon growth of western yellow pine. Journal of Forestry. 16(4): 399-403. doi:10.1093/jof/16.4.399

Turner, R.M. 1956. A study of some features of growth and reproduction of Pinus ponderosa in northern Idaho. Ecology. 37(4): 742-753. doi:10.2307/1933066

Turner, J.S.; Krannitz, P.G. 2001. Conifer density increases in semi-desert habitats of British Columbia in the absence of fire. Northwest Science. 75(2): 176-182. http://hdl.handle.net/2376/967

Turner, M.G.; Gardner, R.H.; Dale, V.H.; O'Neill, R.V. 1989. Predicting the spread of disturbance across heterogeneous landscapes. Oikos. 55(1): 121-129. doi:10.2307/3565881

Turner, M.G.; Hargrove, W.W.; Gardner, R.H.; Romme, W.H. 1994. Effects of fire on landscape heterogeneity in Yellowstone National Park, Wyoming. Journal of Vegetation Science. 5(5): 731-742. doi:10.2307/3235886

Turner, M.G.; Gardner, R.H.; O'Neill, R.V. 2001. Landscape ecology in theory and practice: pattern and process. New York: Springer-Verlag. 401 p. isbn:0-387-95123-7

Turner, D.P.; Ritts, W.D.; Kennedy, R.E.; Gray, A.N.; Yang, Z. 2016. Regional carbon cycle responses to 25 years of variation in climate and disturbance in the US Pacific Northwest. Regional Environmental Change. 16(8): 2345-2355. doi:10.1007/s10113-016-0956-9

Tuten, M.C.; Sánchez Meador, A.; Fulé, P.Z. 2015. Ecological restoration and fine-scale forest structure regulation in southwestern ponderosa pine forests. Forest Ecology and Management. 348: 57-67. doi:10.1016/j.foreco.2015.03.032

Urban, D.L.; O'Neill, R.V.; Shugart, H.H., Jr. 1987. Landscape ecology. BioScience. 37(2): 119-127. doi:10.2307/1310366

Uresk, D.W.; Severson, K.E. 1998. Response of understory species to change in ponderosa pine stocking levels in the Black Hills. Great Basin Naturalist. 58(4): 312-327. https://scholarsarchive.byu.edu/gbn/vol58/iss4/2

Urness, P.J.; Neff, D.J.; Watkins, R.K. 1975. Nutritive value of mule deer forages on ponderosa pine summer range in Arizona. Res. Note RM-304. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 6 p. https://archive.org/download/CAT77681048/CAT77681048.pdf

USDA Forest Service. 1913a. Miscellaneous memoranda and reports regarding ponderosa pine plantations in the Henry Creek area. [Place of publication varies]: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 17 p. On file with: Umatilla NF, Supervisor's Office.

USDA Forest Service. 1913b. Miscellaneous memoranda and reports regarding ponderosa pine plantations in the Kahler Creek area. [Place of publication varies]: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 17 p. On file with: Umatilla NF, Supervisor's Office.

USDA Forest Service. 1916. Sale prospectus: 124,000,000 feet, western yellow pine and other species, lower Middle Fork John Day River unit, Whitman National Forest, Oregon. Portland, OR: USDA Forest Service, District Forester. 18 p.

USDA Forest Service. 1922. Sale prospectus: 890,000,000 board feet, national forest timber, 87 percent western yellow pine; Bear Valley Unit, Malheur National Forest, Oregon. Washington, DC: USDA Forest Service. 24 p. https://archive.org/download/saleprospectus8900unit/saleprospectus8900unit.pdf

USDA Forest Service. 1938. Miscellaneous memoranda regarding a timber sale award appeal, Camas Creek unit. Unpublished materials obtained from National Archives, College Park, MD; record group 95. [Place of publication varies]: USDA Forest Service. 93 p. On file with: USDA Forest Service, Umatilla National Forest, Supervisor's Office, Pendleton, OR.

USDA Forest Service. 1990. Land and resource management plan: Umatilla National Forest. Portland, OR: USDA Forest Service, Pacific Northwest Region. Irregular pagination. http://www.fs.usda.gov/main/umatilla/landmanagement/planning#forest plan

USDA Forest Service. 1993. Region 6 interim old growth definition for Douglas-fir series, grand fir/white fir series, interior Douglas-fir series, lodgepole pine series, Pacific silver fir series, ponderosa pine series, Port-Orford-cedar and tanoak (redwood) series, subalpine fir series, and western hemlock series. Portland, OR: USDA Forest Service, Pacific Northwest Region. Irregular pagination. http://www.blm.gov/or/plans/surveyandmanage/files/16-region6_old_growth_def.pdf

USDA Forest Service. 1994. Decision notice for the continuation of interim management direction establishing riparian, ecosystem and wildlife standards for timber sales; Regional Forester's Forest Plan Amendment #1. Portland, OR: USDA Forest Service, Pacific Northwest Region. 11 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5211880.pdf

USDA Forest Service. 1995. Appendix B; Revised interim direction establishing riparian, ecosystem and wildlife standards for timber sales; Regional Forester's Forest Plan Amendment #2. Portland, OR: USDA Forest Service, Pacific Northwest Region. 14 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5211858.pdf

USDA Forest Service. 1997. Considering all things: summary of the draft environmental impact statements. R6-P&EA-UP-007-97. [Place of publication unknown]: USDA Forest Service; U.S. Depart. of the Interior, Bureau of Land Management. 57 p. https://archive.org/download/consideringallth00unit/consideringallth00unit.pdf

USDA Forest Service. 2001. Benefits of hindsight: reestablishing fire on the landscape. Science Findings. 36: 1-6. https://www.fs.fed.us/pnw/sciencef/scifi36.pdf

USDA Forest Service. 2007. Forest Service open space conservation strategy: Cooperating across boundaries to sustain working and natural landscapes. Washington, DC: U.S. Department of Agriculture, Forest Service. 16 p. usfs-open-space-conservation-strategy

USDA Forest Service. 2012. Increasing the pace of restoration and job creation on our national forests. Washington, DC: USDA Forest Service. 8 p. http://www.fs.fed.us/publications/restoration/restoration.pdf

USDA Forest Service. 2014. Blue Mountains national forests proposed revised land management plan. Baker City, OR: USDA Forest Service, Malheur, Umatilla, and Wallowa-Whitman national forests. 159 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3792953.pdf

USDA Forest Service. 2015a. From accelerating restoration to creating and maintaining resilient landscapes and communities across the nation: Update on progress from 2012. FS-1069. Washington, DC: USDA Forest Service. 26 p. accelerating-restoration-update-2015

USDA Forest Service. 2015b. Legacy tree guide for the Boise National Forest. [Boise, ID]: [USDA Forest Service, Boise National Forest]. 38 p. BNFLegacyTreeGuider

USDA Forest Service. 2018. Potential drought impacts in the Pacific Northwest. Washington, DC: USDA Forest Service, Washington Office, Office of Sustainability and Climate. 12 p. https://www.fs.fed.us/sites/default/files/r6-droughtfactsheet.pdf

USDA Soil Conservation Service. 1941. Survey report: run-off and waterflow retardation and soil erosion prevention for flood control purposes, Walla Walla River Watershed, Washington and Oregon; appendix B: watershed classification, soil, erosion, cover, infiltration survey; land use treatment plans. Spokane, WA: USDA Soil Conservation Service, Region 9. 122 p.

US Global Change Research Program. 2017. Climate science special report: Fourth National Climate Assessment, volume I. In: Wuebbles, D.J.; Fahey, D.W.; Hibbard, K.A.; Dokken, D.J.; Stewart, B.C.; Maycock, T.K., eds. Washington, DC: U.S. Global Change Research Program. 470 p. doi:10.7930/J0J964J6

US Global Change Research Program. 2018. Climate science special report: Fourth National Climate Assessment, volume II. Impacts, risks, and adaptation in the United States. In: Reidmiller, D.R.; Avery, C.W.; Easterling, D.R.; Kunkel, K.E.; Lewis, K.L.M.; Maycock, T.K.; Stewart, B.C., eds. Washington, DC: U.S. Global Change Research Program. 1515 p. doi:10.7930/NCA4.2018

Uzoh, F.C.C. 1999. Response of planted ponderosa pine seedlings to weed control by herbicide in western Montana. Western Journal of Applied Forestry. 14(1): 48-52. doi:10.1093/wjaf/14.1.48

Uzoh, F.C.C. 2001. A height increment equation for young ponderosa pine plantations using precipitation and soil factors. Forest Ecology and Management. 142(1-3): 193-203. doi:10.1016/S0378-1127(00)00350-9

Uzoh, F.C.C.; Mori, S.R. 2012. Applying survival analysis to managed even-aged stands of ponderosa pine for assessment of tree mortality in the western United States. Forest Ecology and Management. 285: 101-122. doi:10.1016/j.foreco.2012.08.006

Uzoh, F.C.C.; Oliver, W.W. 2006. Individual tree height increment model for managed even-aged stands of ponderosa pine throughout the western United States using linear mixed effects models. Forest Ecology and Management. 221(1-3): 147-154. doi:10.1016/j.foreco.2005.09.012

Uzoh, F.C.C.; Oliver, W.W. 2008. Individual tree diameter increment model for managed even-aged stands of ponderosa pine throughout the western United States using a multilevel linear mixed effects model. Forest Ecology and Management. 256(3): 438-445. doi:10.1016/j.foreco.2008.04.046

Vaillant, N.M.; Reinhardt, E.D. 2017. An evaluation of the Forest Service hazardous fuels treatment program – Are we treating enough to promote resiliency or reduce hazard? Journal of Forestry. 115(4): 300-308. doi:10.5849/jof.16-067

Vaillant, N.M.; Fites-Kaufman, J.A.; Stephens, S.L. 2009. Effectiveness of prescribed fire as a fuel treatment in Californian coniferous forests. International Journal of Wildland Fire. 18(2):

165-175. doi:10.1071/WF06065

Vale, T.R., ed. 2002. Fire, native peoples, and the natural landscape. Washington, DC: Island Press. 315 p. isbn:1-55963-889-3

Vander Wall, S.B. 2002. Masting in animal-dispersed pines facilitates seed dispersal. Ecology. 83(12): 3508-3516. doi:10.1890/0012-9658(2002)083[3508:MIADPF]2.0.CO;2

Vander Wall, S.B. 2003. Effects of seed size of wind-dispersed pines (Pinus) on secondary seed dispersal and the caching behavior of rodents. Oikos. 100(1): 25-34. doi:10.1034/j.1600-0706.2003.11973.x

Vander Wall, S.B.; Joyner, J.W. 1998. Secondary dispersal by the wind of winged pine seeds across the ground surface. American Midland Naturalist. 139(2): 365-373. doi:10.1674/0003-0031(1998)139[0365:SDBTWO]2.0.CO;2

Vanderwel, M.C.; Malcolm, J.R.; Mills, S.C. 2007. A meta-analysis of bird responses to uniform partial harvesting across North America. Conservation Biology. 21(5): 1230-1240. doi:10.1111/j.1523-1739.2007.00756.x

Van Deusen, J.L.; Beagle, L.D. 1973. Judging ripeness of seeds in Black Hills ponderosa pine cones. Res. Note RM-235. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. U_S_D_A_Forest_Service_Research_Note_RM

Van Gunst, K.J.; Weisberg, P.J.; Yang, J.; Fan, Y. 2016. Do denser forests have greater risk of tree mortality: A remote sensing analysis of density-dependent forest mortality. Forest Ecology and Management. 359: 19-32. doi:10.1016/j.foreco.2015.09.032

Van Horne, M.L.; Fulé, P.Z. 2006. Comparing methods of reconstructing fire history using fire scars in a southwestern United States ponderosa pine forest. Canadian Journal of Forest Research. 36(4): 855-867. doi:10.1139/X05-289

van Mantgem, P.; Schwartz, M. 2003. Bark heat resistance of small trees in Californian mixed conifer forests: testing some model assumptions. Forest Ecology and Management. 178(3): 341-352. doi:10.1016/S0378-1127(02)00554-6

van Mantgem, P.; Schwartz, M. 2004. An experimental demonstration of stem damage as a predictor of fire-caused mortality for ponderosa pine. Canadian Journal of Forest Research. 34(6): 1343-1347. doi:10.1139/x04-001

van Mantgem, P.J.; Stephenson, N.L.; Byrne, J.C.; Daniels, L.D.; Franklin, J.F.; Fulé, P.Z.; Harmon, M.E.; Larson, A.J.; Smith, J.M.; Taylor, A.H.; Veblen, T.T. 2009. Widespread increase of tree mortality rates in the western United States. Science. 323(5913): 521-524. doi:10.1126/science.1165000

van Mantgem, P.J.; Nesmith, J.C.B.; Keifer, M.; Knapp, E.E.; Flint, A.; Flint, L. 2013. Climatic stress increases forest fire severity across the western United States. Ecology Letters. 16(9): 1151-1156. doi:10.1111/ele.12151

van Mantgem, P.J.; Caprio, A.C.; Stephenson, N.L.; Das, A.J. 2016a. Does prescribed fire promote resistance to drought in low elevation forests of the Sierra Nevada, California, USA? Fire Ecology. 12(1): 13-25. doi:10.4996/fireecology.1201013

van Mantgem, P.J.; Lalemand, L.B.; Keifer, M.; Kane, J.M. 2016b. Duration of fuels reduction following prescribed fire in coniferous forests of U.S. national parks in California and the Colorado Plateau. Forest Ecology and Management. 379: 265-272. doi:10.1016/j.foreco.2016.07.028

Van Pelt, R. 2008. Identifying old trees and forests in eastern Washington. Olympia, WA: Washington State Department of Natural Resources, Land Management Division, Ecosystem Services Section. 168 p. http://www.dnr.wa.gov/Publications/lm_hcp_eastside_oldgrowth_guide.pdf

Van Sickle, F.S.; Hickman, R.D. 1959. The effect of understory competition on the growth rate of ponderosa pine in north central Oregon. Journal of Forestry. 57(11): 852-853. doi:10.1093/jof/57.11.848

Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. Canadian Journal of Forest Research. 7(1): 23-34. doi:10.1139/x77-004

van Wagtendonk, J.W. 1985. Fire suppression effects on fuels and succession in short-fire-interval wilderness ecosystems. In: Lotan, J.E.; Kilgore, B.M.; Fischer, W.C.; Mutch, R.W., tech. coords. Proceedings–symposium and workshop on wilderness fire. Gen. Tech. Rep. INT-182. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station: 119-126. https://archive.org/download/CAT31118982/CAT31118982.pdf

van Wagtendonk, J.W. 2014. Introduction to H. Weaver's article. Fire Ecology. 10(1): 1-13. doi:10.4996/fireecology.1001001

Vance, N.C. 2010. Evaluation of native plant seeds and seeding in the east-side central Cascades ponderosa pine zone. Gen. Tech. Rep. PNW-GTR-823. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 85 p. http://www.treesearch.fs.fed.us/pubs/36921

Vance, R.K.; Edminster, C.B.; Covington, W.W.; Blake, J.A. 2001. Ponderosa pine ecosystems restoration and conservation: steps toward stewardship. Proceedings RMRS-P-22. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 188 p. https://www.fs.usda.gov/treesearch/pubs/6266

Vankat, J.L. 2011. Post-1935 changes in forest vegetation of Grand Canyon National Park, Arizona, USA: Part 1 – ponderosa pine forest. Forest Ecology and Management. 261(3): 309-325. doi:10.1016/j.foreco.2010.05.026

Veblen, T.T.; Lorenz, D.C. 1991. The Colorado Front Range: a century of ecological change. Salt Lake City, UT: University of Utah Press. 186 p. isbn:0-87480-351-9

Veblen, T.T.; Kitzberger, T.; Donnegan, J. 2000. Climatic and human influences on fire regimes in ponderosa pine forests in the Colorado Front Range. Ecological Applications. 10(4): 1178-1195. doi:10.1890/1051-0761(2000)010[1178:CAHIOF]2.0.CO;2

Verbyla, D.L.; Fisher, R.F. 1989a. Effect of aspect on ponderosa pine height and diameter growth. Forest Ecology and Management. 27(2): 93-98. doi:10.1016/0378-1127(89)90031-5

Verbyla, D.L.; Fisher, R.F. 1989b. Ponderosa pine habitat types as an indicator of site quality in the Dixie National Forest, Utah. Western Journal of Applied Forestry. 4(2): 52-54. doi:10.1093/wjaf/4.2.52

Vestal, A.G. 1917. Foothills vegetation in the Colorado Front Range. Botanical Gazette. 64(5): 353-385. doi:10.1086/332167

Vité, J.P. 1961. The influence of water supply on oleoresin exudation pressure and resistance to bark beetle attack in *Pinus ponderosa*. Contributions from Boyce Thompson Institute. 21: 37-66.

Voelker, S.L.; Merschel, A.G.; Meinzer, F.C.; Ulrich, D.E.M.; Spies, T.A.; Still, C.J. 2019. Fire deficits have increased drought sensitivity in dry conifer forests: Fire frequency and tree-ring carbon isotope evidence from central Oregon. Global Change Biology. 25(4): 1247-1262. doi:10.1111/gcb.14543

Voller, J.; Harrison, S., eds. 1998. Conservation biology principles for forested landscapes. Vancouver, BC: UBC Press. 243 p. isbn:0-7748-0630-3

Vose, J.M.; Clark, J.S.; Luce, C.H.; Patel-Weynand, T. 2016. Effects of drought on forests and rangelands in the United States: A comprehensive science synthesis. Gen. Tech. Rep. WO-93b. Washington, DC: USDA Forest Service, Washington Office. 289 p. http://www.fs.fed.us/science-technology/climate-change/drought-forests-and-rangelands

Vose, J.M.; Peterson, D.L.; Luce, C.H.; Patel-Weynand, T. 2019. Effects of drought on forests and rangelands in the United States: translating science into management responses. Gen. Tech. Rep. WO-98. Washington, DC: USDA Forest Service, Washington Office. 227 p. https://www.fs.usda.gov/treesearch/pubs/59158

Vosick, D.; Ostergren, D.M.; Murfitt, L. 2007. Old-growth policy. Ecology and Society. 12(2): 19 (14 p). doi:10.5751/ES-02172-120219

Vyse, A. 1999. Should we continue practicing uneven-aged silviculture in the dry Douglas-fir forests of British Columbia? In: Emmingham, W.H., comp. Proceedings of the IUFRO interdisciplinary uneven-aged management symposium. [Corvallis, OR]: [Oregon State University]: 166-170.

Vyse, A.; Hollstedt, C.; Huggard, D., eds. 1998. Managing the dry Douglas-fir forests of the southern interior: workshop proceedings. Working Pap. 34. Victoria, BC: B.C. Ministry of Forests, Research Branch. 299 p. https://www.for.gov.bc.ca/hfd/pubs/docs/wp/wp34.pdf

Vyse, A.; Ferguson, C.; Simard, S.W.; Kano, T.; Puttonen, P. 2006. Growth of Douglas-fir, lodgepole pine, and ponderosa pine seedlings underplanted in a partially-cut, dry Douglas-fir stand in south-central British Columbia. The Forestry Chronicle. 82(5): 723-732. doi:10.5558/tfc82723-5

Wadsworth, F.H. 1942. Value of small-crowned ponderosa pines in reserve stands in the Southwest. Journal of Forestry. 40(10): 767-771. doi:10.1093/jof/40.10.767

Wagle, R.F.; Eakle, T.W. 1979. A controlled burn reduces the impact of a subsequent wildfire in a ponderosa pine vegetation type. Forest Science. 25(1): 123-129. doi:10.1093/forestscience/25.1.123

Wagle, R.F.; Kitchen, J.H., Jr. 1972. Influence of fire on soil nutrients in a ponderosa pine type. Ecology. 53(1): 118-125. doi:10.2307/1935716

Wagner, M.R.; Mathiasen, R.L. 1985. Dwarf mistletoe–pandora moth interaction and its contribution to ponderosa pine mortality in Arizona. Great Basin Naturalist. 45(3): 423-426. https://scholarsarchive.byu.edu/gbn/vol45/iss3/4

Wagner, M.R.; Zhang, Z.-Y. 1993. Host plant traits associated with resistance of ponderosa pine to the sawfly, Neodiprion fulviceps. Canadian Journal of Forest Research. 23(5): 839-845. doi: 10.1139/x93-109

Wagner, R.G.; Petersen, T.D.; Ross, D.W.; Radosevich, S.R. 1989. Competition thresholds for the survival and growth of ponderosa pine seedlings associated with woody and herbaceous vegetation. New Forests. 3(2): 151-170. doi:10.1007/BF00021579

Wahlenberg, W.G. 1930. Effect of ceanothus brush on western yellow pine plantations in the northern Rocky Mountains. Journal of Agricultural Research. 41(8): 601-612. http://naldc.nal.usda.gov/download/IND43967890/PDF

Walker, R.F.; Geisinger, D.R.; Johnson, D.W.; Ball, J.T. 1995. Interactive effects of atmospheric CO2 enrichment and soil N on growth and ectomycorrhizal colonization of ponderosa pine seedlings. Forest Science. 41(3): 491-500. doi:10.1093/forestscience/41.3.491

Wales, B.C.; Suring, L.H.; Hemstrom, M.A. 2007. Modeling potential outcomes of fire and fuel management scenarios on the structure of forested habitats in northeast Oregon, USA. Landscape and Urban Planning. 80(3): 223-236. doi:10.1016/j.landurbplan.2006.10.006

Walker, R.F.; Cheng, W.; Johnson, D.W. 2010. Mycorrhization of ponderosa pine in a second-growth Sierra Nevada forest. Western North American Naturalist. 70(1): 1-8. doi:10.3398/064.070.0101

Walker, R.B.; Coop, J.D.; Parks, S.A.; Trader, L. 2018. Fire regimes approaching historic norms reduce wildfire-facilitated conversion from forest to non-forest. Ecosphere. 9(4): e02182. doi:10.1002/ecs2.2182

Wallin, K.F.; Kolb, T.E.; Skov, K.R.; Wagner, M.R. 2003. Effects of crown scorch on ponderosa pine resistance to bark beetles in northern Arizona. Environmental Entomology. 32(3): 652-661. doi:10.1603/0046-225X-32.3.652

Wallin, K.F.; Kolb, T.E.; Skov, K.R.; Wagner, M. 2008. Forest management treatments, tree resistance, and bark beetle resource utilization in ponderosa pine forests of northern Arizona. Forest Ecology and Management. 255(8-9): 3263-3269. doi:10.1016/j.foreco.2008.01.075

Walsh, M.K.; Marlon, J.R.; Goring, S.J.; Brown, K.J.; Gavin, D.G. 2015. A regional perspective on Holocene fire–climate–human interactions in the Pacific Northwest of North America. Annals of the Association of American Geographers. 105(6): 1135-1157. doi:10.1080/00045608.2015.1064457

Walstad, J.D.; Radosevich, S.R.; Sandberg, D.V., eds. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p. isbn:0-87071-359-0

Wang, C.-W. 1977. Genetics of ponderosa pine. Res. Paper WO-34. Washington, DC: USDA Forest Service. 24 p. https://archive.org/download/geneticsofponder34wang/geneticsofponder34wang.pdf

Waples, R.S.; Beechie, T.; Pess, G.R. 2009. Evolutionary history, habitat disturbance regimes, and anthropogenic changes: What do these mean for resilience of Pacific salmon populations? Ecology and Society. 14(1): 3 (18 p). doi:10.5751/ES-02626-140103

Ward, F.R.; Sandberg, D.V. 1981. Predictions of fire behavior and resistance to control for use with photo series for the ponderosa pine type, ponderosa pine and associated species type, and lodgepole pine type. Gen. Tech. Rep. PNW-GTR-115. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 46 p. https://www.fs.usda.gov/treesearch/pubs/7558

Wardle, D.A.; Nilsson, M.-C.; Gallet, C.; Zackrisson, O. 1998. An ecosystem-level perspective of allelopathy. Biological Reviews. 73(3): 305-319. doi:10.1111/j.1469-185X.1998.tb00033.x

Waring, R.H. 1987. Characteristics of trees predisposed to die. BioScience. 37(8): 569-574. doi:10.2307/1310667

Waring, R.H.; Law, B.E. 2001. The ponderosa pine ecosystem and environmental stress: past, present and future. Tree Physiology. 21(5): 273-274. doi:10.1093/treephys/21.5.273

Waring, R.H.; Pitman, G.B. 1985. Modifying lodgepole pine stands to change susceptibility to mountain pine beetle attack. Ecology. 66(3): 889-897. doi:10.2307/1940551

Warren, J.M.; Brooks, J.R.; Meinzer, F.C.; Eberhart, J.L. 2008. Hydraulic redistribution of water from *Pinus ponderosa* trees to seedlings: evidence for an ectomycorrhizal pathway. New Phytologist. 178(2): 382-394. doi:10.1111/j.1469-8137.2008.02377.x

Watrud, E.; Zensen, F.; Darbyshire, R. 2012. Laws affecting reforestation on USDA Forest Service

lands. Tree Planters' Notes. 55(2): 39-42.
laws-affecting-reforestation-on-usda-forest-service-lands

Watson, E.; Luckman, B.H. 2002. The dendroclimatic signal in Douglas-fir and ponderosa pine tree-ring chronologies from the southern Canadian Cordillera. Canadian Journal of Forest Research. 32(10): 1858-1874. doi:10.1139/x02-096

Way, D.A. 2013. Will rising CO2 and temperatures exacerbate the vulnerability of trees to drought? Tree Physiology. 33(8): 775-778. doi:10.1093/treephys/tpt069

Wayman, R.B.; North, M. 2007. Initial response of a mixed-conifer understory plant community to burning and thinning restoration treatments. Forest Ecology and Management. 239(1-3): 32-44. doi:10.1016/j.foreco.2006.11.011

Weakly, H.E. 1943. A tree-ring record of precipitation in western Nebraska. Journal of Forestry. 41(11): 816-819. doi:10.1093/jof/41.11.816

Weaver, J.E. 1917. A study of the vegetation of southeastern Washington and adjacent Idaho. University Studies. 17(1): 1-133.
http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1510&context=agronomyfacpub

Weaver, H. 1943. Fire as an ecological and silvicultural factor in the ponderosa-pine region of the Pacific slope. Journal of Forestry. 41(1): 7-14. doi:10.1093/jof/41.1.7

Weaver, H. 1947a. Fire – nature's thinning agent in ponderosa pine stands. Journal of Forestry. 45(6): 437-444. doi:10.1093/jof/45.6.437

Weaver, H. 1947b. Management problems in the ponderosa pine region. Northwest Science. 21(4): 160-163.

Weaver, H. 1950. Shoals and reefs in ponderosa pine silviculture. Journal of Forestry. 48(1): 21-22. doi:10.1093/jof/48.1.21

Weaver, H. 1952. A preliminary report on prescribed burning in virgin ponderosa pine. Journal of Forestry. 50(9): 662-667. doi:10.1093/jof/50.9.662

Weaver, H. 1957a. Effects of prescribed burning in ponderosa pine. Journal of Forestry. 55(2): 133-138. doi:10.1093/jof/55.2.133

Weaver, H. 1957b. Effects of prescribed burning in second growth ponderosa pine. Journal of Forestry. 55(11): 823-826. doi:10.1093/jof/55.11.823

Weaver, H. 1961. Ecological changes in the ponderosa pine forest of Cedar Valley in southern Washington. Ecology. 42(2): 416-420. doi:10.2307/1932097

Weaver, H. 1967a. Fire and its relationship to ponderosa pine. In: Proceedings of the annual Tall Timbers fire ecology conference no. 7. Tallahassee, FL: Tall Timbers Research Station: 127-149. http://talltimbers.org/wp-content/uploads/2014/03/Weaver1967_op.pdf

Weaver, H. 1967b. Fire as a continuing ecological factor in perpetuation of ponderosa pine forests in western United States. Advancing Frontiers of Plant Science. 18: 137-157.

Webb, W.L.; Lauenroth, W.K.; Szarek, S.R.; Kinerson, R.S. 1983. Primary production and abiotic controls in forests, grasslands, and desert ecosystems in the United States. Ecology. 64(1): 134-151. doi:10.2307/1937336

Weber, J.C.; Sorensen, F.C. 1990. Effects of stratification and temperature on seed germination speed and uniformity in central Oregon ponderosa pine (*Pinus ponderosa*, Dougl. ex Laws.). Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 13 p.
https://www.fs.usda.gov/treesearch/pubs/20546

Weber, J.C.; Sorensen, F.C. 1992. Geographic variation in speed of seed germination in central

Oregon ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.). Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 12 p. https://www.fs.usda.gov/treesearch/pubs/20559

Webster, K.M.; Halpern, C.B. 2010. Long-term vegetation responses to reintroduction and repeated use of fire in mixed-conifer forests of the Sierra Nevada. Ecosphere. 1(5): art9 (27 p). doi:10.1890/ES10-00018.1

Weed, A.S.; Bentz, B.J.; Ayres, M.P.; Holmes, T.P. 2015. Geographically variable response of *Dendroctonus ponderosae* to winter warming in the western United States. Landscape Ecology. 30(6): 1075-1093. doi:10.1007/s10980-015-0170-z

Wei, L.; Marshall, J.D.; Zhang, J.; Zhou, H.; Powers, R.F. 2014. 3-PG simulations of young ponderosa pine plantations under varied management intensity: Why do they grow so differently? Forest Ecology and Management. 313: 69-82. doi:10.1016/j.foreco.2013.10.035

Weidman, R.H. 1920. A study of windfall loss of western yellow pine in selection cuttings fifteen to thirty years old. Journal of Forestry. 18(6): 616-622. doi:10.1093/jof/18.6.616

Weidman, R.H. 1921. Forest succession as a basis of the silviculture of western yellow pine. Journal of Forestry. 19(8): 877-885. doi:10.1093/jof/19.8.877

Weidman, R.H. 1939. Evidences of racial influence in a 25-year test of ponderosa pine. Journal of Agricultural Research. 59(12): 855-887. https://naldc.nal.usda.gov/download/IND43969272/PDF

Weidman, R.H.; Silcox, F.A. 1936. Timber growing and logging practice in ponderosa pine in the Northwest. Tech. Bull. No. 511. Washington, DC: U.S. Depart. of Agriculture. 91 p. https://naldc.nal.usda.gov/download/CAT86200506/PDF

Weinstein, D.A.; Laurence, J.A.; Retzlaff, W.A.; Kern, J.S.; Lee, E.H.; Hogsett, W.E.; Weber, J. 2005. Predicting the effects of tropospheric ozone on regional productivity of ponderosa pine and white fir. Forest Ecology and Management. 205(1-3): 73-89. doi:10.1016/j.foreco.2004.10.007

Weir, J.R. 2009. Conducting prescribed fires: A comprehensive manual. College Station, TX: Texas A&M University Press. 194 p. isbn:978-1-60344-134-6

Weisshaupt, B.R.; Carroll, M.S.; Blatner, K.A.; Robinson, W.D.; Jakes, P.J. 2005. Acceptability of smoke from prescribed forest burning in the northern inland West: A focus group approach. Journal of Forestry. 103(4): 189-193. doi:10.1093/jof/103.4.189

Weisz, R.; Triepke, J.; Truman, R. 2009. Evaluating the ecological sustainability of a ponderosa pine ecosystem on the Kaibab Plateau in northern Arizona. Fire Ecology. 5(1): 100-114. doi:10.4996/fireecology.0501100

Welch, K.R.; Safford, H.D.; Young, T.P. 2016. Predicting conifer establishment post wildfire in mixed conifer forests of the North American Mediterranean-climate zone. Ecosphere. 7(12): e01609. doi:10.1002/ecs2.1609

Wells, O.O. 1964. Geographic variation in ponderosa pine. I. The ecotypes and their distribution. Silvae Genetica. 13(4): 89-103. Silvae_Genetica/1964/Vol._13_Heft_5/13_5_125

Wells, A.F. 2006. Deep canyon and subalpine riparian and wetland plant associations of the Malheur, Umatilla, and Wallowa-Whitman National Forests. Gen. Tech. Rep. GTR-PNW-682. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 277 p. http://www.treesearch.fs.fed.us/pubs/24936

Wenny, D.L.; Swanson, D.J.; Dumroese, R.K. 2002. The chilling optimum of Idaho and Arizona ponderosa pine buds. Western Journal of Applied Forestry. 17(3): 117-121. doi:10.1093/wjaf/17.3.117

West, N.E. 1968. Rodent-influenced establishment of ponderosa pine and bitterbrush seedlings in central Oregon. Ecology. 49(5): 1009-1011. doi:10.2307/1936557

West, N.E. 1969. Tree patterns in central Oregon ponderosa pine forests. American Midland Naturalist. 81(2): 584-590. doi:10.2307/2423994

West, J.; Julius, S.; Kareiva, P.; Enquist, C.; Lawler, J.; Petersen, B.; Johnson, A.; Shaw, M. 2009. U.S. natural resources and climate change: concepts and approaches for management adaptation. Environmental Management. 44(6): 1001-1021. doi:10.1007/s00267-009-9345-1

West, D.R.; Bernklau, E.J.; Bjostad, L.B.; Jacobi, W.R. 2016. Host defense mechanisms against bark beetle attack differ between ponderosa and lodgepole pines. Forests. 7(10): 248. doi:10.3390/f7100248

Westerling, A.L. 2016. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring. Philosophical Transactions of the Royal Society B: Biological Sciences. 371(1696): 20150178 (12 p). doi:10.1098/rstb.2015.0178

Westerling, A.L.; Bryant, B.P. 2008. Climate change and wildfire in California. Climatic Change. 87(1): 231-249. doi:10.1007/s10584-007-9363-z

Westerling, A.L.; Swetnam, T.W. 2003. Interannual to decadal drought and wildfire in the western United States. Eos, Transactions American Geophysical Union. 84(49): 545-555. doi:10.1029/2003EO490001

Westerling, A.L.; Gershunov, A.; Brown, T.J.; Cayan, D.R.; Dettinger, M.D. 2003. Climate and wildfire in the western United States. Bulletin of the American Meteorological Society. 84(5): 595-604. doi:10.1175/BAMS-84-5-595

Westerling, A.L.; Hidalgo, H.G.; Cayan, D.R.; Swetnam, T.W. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science. 313(5789): 940-943. doi:10.1126/science.1128834

Westerling, A.L.; Turner, M.G.; Smithwick, E.A.H.; Romme, W.H.; Ryan, M.G. 2011. Continued warming could transform Greater Yellowstone fire regimes by mid-21st century. Proceedings of the National Academy of Sciences. 108(32): 13165-13170. doi:10.1073/pnas.1110199108

Westlind, D.J.; Kelsey, R.G. 2019. Predicting post-fire attack of red turpentine or western pine beetle on ponderosa pine and its impact on mortality probability in Pacific Northwest forests. Forest Ecology and Management. 434: 181-192. doi:10.1016/j.foreco.2018.12.021

Westlind, D.J.; Kerns, B.K. 2017. Long-term effects of burn season and frequency on ponderosa pine forest fuels and seedlings. Fire Ecology. 13(3): 42-61. doi:10.4996/fireecology.130304261

Whelan, R.J. 1995. The ecology of fire. Cambridge, UK: Cambridge University Press. 346 p. isbn:0-521-32872-1

White, A.S. 1985. Presettlement regeneration patterns in a southwestern ponderosa pine stand. Ecology. 66(2): 589-594. doi:10.2307/1940407

White, C.S. 1986. Effects of prescribed fire on rates of decomposition and nitrogen mineralization in a ponderosa pine ecosystem. Biology and Fertility of Soils. 2(2): 87-95. doi:10.1007/BF00257585

White, E.M.; Thompson, W.W.; Gartner, F.R. 1973. Heat effects on nutrient release from soils under ponderosa pine. Journal of Range Management. 26(1): 22-24. https://journals.uair.arizona.edu/index.php/jrm/article/download/6133/5743

White, A.S.; Cook, J.E.; Vose, J.M. 1991. Effects of fire and stand structure on grass phenology in a ponderosa pine forest. American Midland Naturalist. 126(2): 269-278. doi:10.2307/2426102

White, P.S.; Harrod, J.; Romme, W.H.; Betancourt, J. 1999. Disturbance and temporal dynamics. In: Szaro, R.C.; Johnson, N.C.; Sexton, W.T.; Malk, A.J., eds. Ecological stewardship: a common reference for ecosystem management; volume II. Kidlington, Oxford, UK: Elsevier Science, Ltd: 281-312.

White, R.; Johnson, M.; Vaillant, N.; Fried, J. 2018. Fuel treatments: Are we doing enough? Science Update 25. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 15 p. https://www.fs.usda.gov/treesearch/pubs/57406

White, E.M.; Lindberg, K.; Davis, E.J.; Spies, T.A. 2019. Use of science and modeling by practitioners in landscape-scale management decisions. Journal of Forestry. 117(3): 267-279. doi:10.1093/jofore/fvz007

White, M.A.; Cornett, M.W.; Frerker, K.; Etterson, J.R. 2020. Partnerships to take on climate change: Adaptation forestry and conifer strongholds projects in the Northwoods, Minnesota, USA. Journal of Forestry. 118(3): 219-232. doi:10.1093/jofore/fvaa005

Whiteside, J.M. 1951. The western pine beetle: a serious enemy of ponderosa pine. Circular No. 864. Washington, DC: USDA Forest Service. 10 p. https://archive.org/download/westernpinebeetl864whit/westernpinebeetl864whit.pdf

Whitlock, C.; Shafer, S.L.; Marlon, J. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern US and the implications for ecosystem management. Forest Ecology and Management. 178(1-2): 5-21. doi:10.1016/S0378-1127(03)00051-3

Wickman, B.E. 1978. Tree mortality and top-kill related to defoliation by the Douglas-fir tussock moth in the Blue Mountains outbreak. Res. Pap. PNW-233. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 47 p. https://archive.org/download/CAT92273162/CAT92273162.pdf

Wickman, B.E. 1990. Old-growth forests and history of insect outbreaks. Northwest Environmental Journal. 6(2): 401-403.

Wickman, B.E. 1992. Forest health in the Blue Mountains: the influence of insects and disease. Gen. Tech. Rep. PNW-GTR-295. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 15 p. http://www.treesearch.fs.fed.us/pubs/9032

Wickman, B.E.; Mason, R.R.; Trostle, G.C. 1981. Douglas-fir tussock moth. Forest Insect & Disease Leaflet 86. [Place of publication unknown]: USDA Forest Service. 10 p. http://na.fs.fed.us/spfo/pubs/fidls/tussock/fidl-tuss.htm

Wickman, B.E.; Mason, R.R.; Swetnam, T.W. 1994. Searching for long-term patterns of forest insect outbreaks. In: Leather, S.R.; Walters, K.F.A.; Mills, N.J.; Watt, A.D., eds. Individuals, populations and patterns in ecology. Andover, Hampshire, UK: Intercept, Ltd: 251-261.

Wiedinmyer, C.; Hurteau, M.D. 2010. Prescribed fire as a means of reducing forest carbon emissions in the western United States. Environmental Science and Technology. 44(6): 1926-1932. doi:10.1021/es902455e

Wilcox, B.P.; Newman, B.D.; Brandes, D.; Davenport, D.W.; Reid, K. 1997. Runoff from a semi-arid ponderosa pine hillslope in New Mexico. Water Resources Research. 33(10): 2301-2314. doi:10.1029/97WR01691

Wilkes, C. 1844. Narrative of the United States exploring expedition during the years 1838, 1839, 1840, 1841, 1842. Page 251 in volume V. Philadelphia: C. Sherman, publisher. (5 volumes, plus an atlas).

Williams, J.T. 1978. Management implications from a timber type evaluation of Oregon and Washington tussock moth outbreak areas. Master of Science thesis. Seattle, WA: University of Washington. 69 p.

Williams, G.W. 2000. Early fire use in Oregon. Fire Management Today. 60(3): 13-20. https://www.fs.fed.us/file/40943/download?token=E2qLLR6G

Williams, J. 2004. Managing fire-dependent ecosystems: we need a public lands policy debate. Fire Management Today. 64(2): 6-11. http://www.fs.fed.us/sites/default/files/legacy_files/fire-management-today/64-2.pdf

Williams, A.P.; Abatzoglou, J.T. 2016. Recent advances and remaining uncertainties in resolving past and future climate effects on global fire activity. Current Climate Change Reports. 2(1): 1-14. doi:10.1007/s40641-016-0031-0

Williams, M.A.; Baker, W.L. 2010. Bias and error in using survey records for ponderosa pine landscape restoration. Journal of Biogeography. 37(4): 707-721. doi:10.1111/j.1365-2699.2009.02257.x

Williams, M.A.; Baker, W.L. 2012. Spatially extensive reconstructions show variable-severity fire and heterogeneous structure in historical western United States dry forests. Global Ecology and Biogeography. 21(10): 1042-1052. doi:10.1111/j.1466-8238.2011.00750.x

Williams, M.A.; Baker, W.L. 2013. Variability of historical forest structure and fire across ponderosa pine landscapes of the Coconino Plateau and south rim of Grand Canyon National Park, Arizona, USA. Landscape Ecology. 28(2): 297-310. doi:10.1007/s10980-012-9835-z

Williams, J.D.; Buckhouse, J.C. 1993. Winter logging and erosion in a ponderosa pine forest in northeastern Oregon. Western Journal of Applied Forestry. 8(1): 19-23. doi:10.1093/wjaf/8.1.19

Williams, J.T.; Martin, R.E.; Pickford, S.G. 1980. Silvicultural and fire management implications from a timber type evaluation of tussock moth outbreak areas. In: Martin, R.E.; Edmonds, R.L.; Faulkner, D.A.; Harrington, J.B.; Fuquay, D.M.; Stocks, B.J.; Barr, S., eds. Proceedings: sixth conference on fire and forest meteorology. Washington, DC: Society of American Foresters: 191-196.

Williams, R.E.; Shaw, C.G., III; Wargo, P.M.; Sites, W.H. 1986. Armillaria root disease. Forest Insect & Disease Leaflet 78. [Place of publication unknown]: USDA Forest Service. 8 p. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_043192.pdf

Williams, M.; Law, B.E.; Anthoni, P.M.; Unsworth, M.H. 2001. Use of a simulation model and ecosystem flux data to examine carbon-water interactions in ponderosa pine. Tree Physiology. 21(5): 287-298. doi:10.1093/treephys/21.5.287

Williams, A.P.; Allen, C.D.; Millar, C.I.; Swetnam, T.W.; Michaelsen, J.; Still, C.J.; Leavitt, S.W. 2010. Forest responses to increasing aridity and warmth in the southwestern United States. Proceedings of the National Academy of Sciences of the United States of America. 107(50): 21289-21294. doi:10.1073/pnas.0914211107

Williams, C.A.; Collatz, G.J.; Masek, J.; Goward, S.N. 2012. Carbon consequences of forest disturbance and recovery across the conterminous United States. Global Biogeochemical Cycles. 26(1): GB1005 (13 p). doi:10.1029/2010GB003947

Williams, A.P.; Allen, C.D.; Macalady, A.K.; Griffin, D.; Woodhouse, C.A.; Meko, D.M.; Swetnam, T.W.; Rauscher, S.A.; Seager, R.; Grissino-Mayer, H.D.; Dean, J.S.; Cook, E.R.; Gangodagamage, C.; Cai, M.; McDowell, N.G. 2013. Temperature as a potent driver of regional forest drought stress and tree mortality. Nature Climate Change. 3(3): 292-297. doi:10.1038/nclimate1693

Williams, C.A.; Gu, H.; MacLean, R.; Masek, J.G.; Collatz, G.J. 2016. Disturbance and the carbon balance of US forests: A quantitative review of impacts from harvests, fires, insects, and droughts. Global and Planetary Change. 143: 66-80. doi:10.1016/j.gloplacha.2016.06.002

Williamson, N.M. 1999. Crown fuel characteristics, stand structure, and fire hazard in riparian forests of the Blue Mountains, Oregon. M.S. thesis. Seattle, WA: University of Washington. 98 p.

Willms, J.; Bartuszevige, A.; Schwilk, D.W.; Kennedy, P.L. 2017. The effects of thinning and burning on understory vegetation in North America: A meta-analysis. Forest Ecology and Management. 392: 184-194. doi:10.1016/j.foreco.2017.03.010

Wilson, J.S.; Baker, P.J. 1998. Mitigating fire risk to late-successional forest reserves on the east slope of the Washington Cascade range, USA. Forest Ecology and Management. 110(1-3): 59-75. doi:10.1016/S0378-1127(98)00274-6

Wilson, A.K.; Greenway, G.H. 1957. Costs of logging virgin ponderosa pine in central Idaho. Res. Paper No. 51. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 14 p. https://archive.org/download/CAT31005739/CAT31005739.pdf

Wilson, K.; Morren, G.E.B., Jr. 1990. Systems approaches for improvement in agriculture and resource management. New York: Macmillan Publishing Company. 361 p. isbn:0-02-428411-4

Wilson, C.; Kampf, S.K.; Wagenbrenner, J.W.; MacDonald, L.H. 2018. Rainfall thresholds for post-fire runoff and sediment delivery from plot to watershed scales. Forest Ecology and Management. 430: 346-356. doi:10.1016/j.foreco.2018.08.025

Wilson, N.; Bradstock, R.; Bedward, M. 2021. Comparing forest carbon stock losses between logging and wildfire in forests with contrasting responses to fire. Forest Ecology and Management. 481: 118701 (9 p). doi:10.1016/j.foreco.2020.118701

Wingfield, D.W. 1955. Trees versus water and grass. Journal of Range Management. 8(4): 149-150. doi:10.2307/3894213

Winnett, S.M. 1998. Potential effects of climate change on U.S. forests: a review. Climate Research. 11(1): 39-49. doi:10.3354/cr011039

Wisdom, M.J.; Holthausen, R.S.; Wales, B.C.; Hargis, C.D.; Saab, V.A.; Lee, D.C.; Hann, W.J.; Rich, T.D.; Rowland, M.M.; Murphy, W.J.; Eames, M.R. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale trends and management implications. Gen. Tech. Rep. PNW-GTR-485. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 529 p. http://www.treesearch.fs.fed.us/pubs/3081

Wissmar, R.C. 2004. Riparian corridors of Eastern Oregon and Washington: Functions and sustainability along lowland-arid to mountain gradients. Aquatic Sciences. 66(4): 373-387. doi:10.1007/s00027-004-0720-y

With, K.A.; Crist, T.O. 1995. Critical thresholds in species' responses to landscape structure.

Ecology. 76(8): 2446-2459. doi:10.2307/2265819

Wolk, B.; Rocca, M.E. 2009. Thinning and chipping small-diameter ponderosa pine changes understory plant communities on the Colorado Front Range. Forest Ecology and Management. 257(1): 85-95. doi:10.1016/j.foreco.2008.08.014

Wollum, A.G., II; Schubert, G.H. 1975. Effect of thinning on the foliage and forest floor properties of ponderosa pine stands. Soil Science Society of America Proceedings. 39(5): 968-972. doi:10.2136/sssaj1975.03615995003900050044x

Wondzell, S.M.; King, J.G. 2003. Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions. Forest Ecology and Management. 178(1-2): 75-87. doi:10.1016/S0378-1127(03)00054-9

Wondzell, S.M.; Burnett, K.M.; Kline, J.D. 2007. Landscape analysis: Projecting the effects of management and natural disturbances on forest and watershed resources of the Blue Mountains, Oregon, USA. Landscape and Urban Planning. 80(3): 193-197. doi:10.1016/j.landurbplan.2006.10.003

Wood, D.B. 1988. Costs of prescribed burning in southwestern ponderosa pine. Western Journal of Applied Forestry. 3(4): 115-119. doi:10.1093/wjaf/3.4.115

Woodall, C.W.; Monleon, V.J. 2008. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. Gen. Tech. Rep. NRS-22. Newtown Square, PA: USDA Forest Service, Northern Research Station. 68 p. https://www.fs.usda.gov/treesearch/pubs/13615

Woodall, C.W.; Fiedler, C.E.; Milner, K.S. 2003a. Intertree competition in uneven-aged ponderosa pine stands. Canadian Journal of Forest Research. 33(9): 1719-1726. doi:10.1139/x03-096

Woodall, C.W.; Fiedler, C.E.; Milner, K.S. 2003b. Stand density index in uneven-aged ponderosa pine stands. Canadian Journal of Forest Research. 33(1): 96-100. doi:10.1139/x02-168

Woods, S.W.; Balfour, V.N. 2010. The effects of soil texture and ash thickness on the post-fire hydrological response from ash-covered soils. Journal of Hydrology. 393(3): 274-286. doi:10.1016/j.jhydrol.2010.08.025

Wooldridge, D.D.; Weaver, H. 1965. Some effects of thinning a ponderosa pine thicket with a prescribed fire, II. Journal of Forestry. 63(2): 92-95. doi:10.1093/jof/63.2.92

Woolsey, T.S., Jr. 1911. Western yellow pine in Arizona and New Mexico. Bull. No. 101. Washington, DC: USDA Forest Service. 64 p. https://www.archive.org/download/westernyellowpin10wool/westernyellowpin10wool.pdf

Worrall, J.J.; Marchetti, S.B.; Egeland, L.; Mask, R.A.; Eager, T.; Howell, B. 2010. Effects and etiology of sudden aspen decline in southwestern Colorado, USA. Forest Ecology and Management. 260(5): 638-648. doi:10.1016/j.foreco.2010.05.020

Wortendyke, J. 1968. Appraisal of mountain pine beetle caused tree mortality in a young ponderosa pine stand on the Wallowa-Whitman National Forest. Portland, OR: USDA Forest Service, Insect and Disease Control Branch, Division of Timber Management, Pacific Northwest Region. 13 p.

Wright, E. 1957. Importance of mycorrhizae to ponderosa pine seedlings. Forest Science. 3(3): 275-280. doi:10.1093/forestscience/3.3.275

Wright, E. 1971. Mycorrhizae on Douglas-fir and ponderosa pine seedlings. Research Bulletin 13. Corvallis, OR: Oregon State University, School of Forestry, Forest Research Laboratory. 36 p.

https://ir.library.oregonstate.edu/downloads/k3569565j?locale=en

Wright, H.A. 1978. The effect of fire on vegetation in ponderosa pine forests: a state-of-the-art review. Pub. No. T-9-199. Lubbock, TX: Texas Tech University, College of Agricultural Sciences, Depart. of Range and Wildlife Management. 21 p.

Wright, C.S.; Agee, J.K. 2004. Fire and vegetation history in the Eastern Cascade Mountains, Washington. Ecological Applications. 14(2): 443-459. doi:10.1890/02-5349

Wright, R.J.; Hart, S.C. 1997. Nitrogen and phosphorus status in a ponderosa pine forest after 20 years of interval burning. Ecoscience. 4(4): 526-533. doi:10.1080/11956860.1997.11682432

Wright, P.; Harmon, M.; Swanson, F. 2002. Assessing the effect of fire regime on coarse woody debris. In: Laudenslayer, W.F., Jr.; Shea, P.J.; Valentine, B.E.; Weatherspoon, C.P.; Lisle, T.E., eds. Proceedings of the symposium on the ecology and management of dead wood in western forests. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: USDA Forest Service, Pacific Southwest Research Station: 621-634. http://www.treesearch.fs.fed.us/pubs/6718

Wright, C.S.; Evans, A.M.; Restaino, J.C. 2017. Decomposition rates for hand-piled fuels. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 18 p. https://www.treesearch.fs.fed.us/pubs/53677

Wright, C.S.; Evans, A.M.; Grove, S.; Haubensak, K.A. 2019. Pile age and burn season influence fuelbed properties, combustion dynamics, fuel consumption, and charcoal formation when burning hand piles. Forest Ecology and Management. 439: 146-158. doi:10.1016/j.foreco.2019.02.005

Wu, T.; Kim, Y.-S. 2013. Pricing ecosystem resilience in frequent-fire ponderosa pine forests. Forest Policy and Economics. 27: 8-12. doi:10.1016/j.forpol.2012.11.002

Wuebbles, D.J.; Fahey, D.W.; Hibbard, K.A.; Dokken, D.J.; Stewart, B.C.; Maycock, T.K., eds. 2017. Climate science special report: Fourth National Climate Assessment, Volume I. Washington, DC: U.S. Global Change Research Program. 470 p. https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf

Wurtzebach, Z.; DeRose, R.J.; Bush, R.R.; Goeking, S.A.; Healey, S.; Menlove, J.; Pelz, K.A.; Schultz, C.; Shaw, J.D.; Witt, C. 2020. Supporting national forest system planning with Forest Inventory and Analysis data. Journal of Forestry. 118(3): 289-306. doi:10.1093/jofore/fvz061

Wyant, J.G.; Laven, R.D.; Omi, P.N. 1983. Fire effects on shoot growth characteristics of ponderosa pine in Colorado. Canadian Journal of Forest Research. 13(4): 620-625. doi:10.1139/x83-089

Wyant, J.G.; Omi, P.N.; Laven, R.D. 1986. Fire induced tree mortality in a Colorado ponderosa pine/Douglas-fir stand. Forest Science. 32(1): 49-59. doi:10.1093/forestscience/32.1.49

Xu, M.; DeBiase, T.A.; Qi, Y.; Goldstein, A.; Liu, Z. 2001. Ecosystem respiration in a young ponderosa pine plantation in the Sierra Nevada Mountains, California. Tree Physiology. 21(5): 309-318. doi:10.1093/treephys/21.5.309

Yager, L.Y.; Hinderliter, M.G.; Heise, C.D.; Epperson, D.M. 2007. Gopher tortoise response to habitat management by prescribed burning. Journal of Wildlife Management. 71(2): 428-434. doi:10.2193/2006-337

Yazvenko, S.B.; Rapport, D.J. 1997. The history of ponderosa pine pathology: implications for management. Journal of Forestry. 95(12): 16-20. doi:10.1093/jof/95.12.16

Yocom-Kent, L.L.; Fulé, P.Z.; Bunn, W.A.; Gdula, E.G. 2015. Historical high-severity fire patches in mixed-conifer forests. Canadian Journal of Forest Research. 45(11): 1587-1596. doi:10.1139/cjfr-2015-0128

York, R.A.; Battles, J.J.; Heald, R.C. 2003. Edge effects in mixed conifer group selection openings: tree height response to resource gradients. Forest Ecology and Management. 179(1-3): 107-121. doi:10.1016/S0378-1127(02)00487-5

York, R.A.; Heald, R.C.; Battles, J.J.; York, J.D. 2004. Group selection management in conifer forests: relationships between opening size and tree growth. Canadian Journal of Forest Research. 34(3): 630-641. doi:10.1139/x03-222

York, R.A.; Battles, J.J.; Wenk, R.C.; Saah, D. 2012. A gap-based approach for regenerating pine species and reducing surface fuels in multi-aged mixed conifer stands in the Sierra Nevada, California. Forestry. 85(2): 203-213. doi:10.1093/forestry/cpr058

Young, J.A.; Evans, R.A. 1981. Demography and fire history of a western juniper stand. Journal of Range Management. 34(6): 501-505. https://journals.uair.arizona.edu/index.php/jrm/article/download/7248/6860

Young, D.J.N.; Stevens, J.T.; Earles, J.M.; Moore, J.; Ellis, A.; Jirka, A.L.; Latimer, A.M. 2017. Long-term climate and competition explain forest mortality patterns under extreme drought. Ecology Letters. 20(1): 78-86. doi:10.1111/ele.12711

Young, D.J.N.; Meyer, M.; Estes, B.; Gross, S.; Wuenschel, A.; Restaino, C.; Safford, H.D. 2020. Forest recovery following extreme drought in California, USA: natural patterns and effects of pre-drought management. Ecological Applications. 30(1): e02002 (18 p). doi:10.1002/eap.2002

Youngblood, A. 2001. Old-growth forest structure in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 110-118. http://hdl.handle.net/2376/987

Youngblood, A. 2010. Thinning and burning in dry coniferous forests of the western United States: effectiveness in altering diameter distributions. Forest Science. 56(1): 46-59. doi:10.1093/forestscience/56.1.46

Youngblood, A.; Max, T.; Coe, K. 2004. Stand structure in eastside old-growth ponderosa pine forests of Oregon and northern California. Forest Ecology and Management. 199(2-3): 191-217. doi:10.1016/j.foreco.2004.05.056

Youngblood, A.; Metlen, K.L.; Coe, K. 2006. Changes in stand structure and composition after restoration treatments in low elevation dry forests of northeastern Oregon. Forest Ecology and Management. 234(1-3): 143-163. doi:10.1016/j.foreco.2006.06.033

Youngblood, A.; Grace, J.B.; McIver, J.D. 2009. Delayed conifer mortality after fuel reduction treatments: interactive effects of fuel, fire intensity, and bark beetles. Ecological Applications. 19(2): 321-337. doi:10.1890/07-1751.1

Zachmann, L.J.; Shaw, D.W.H.; Dickson, B.G. 2018. Prescribed fire and natural recovery produce similar long-term patterns of change in forest structure in the Lake Tahoe basin, California. Forest Ecology and Management. 409: 276-287. doi:10.1016/j.foreco.2017.11.013

Zald, H.S.J.; Gray, A.N.; North, M.; Kern, R.A. 2008. Initial tree regeneration responses to fire and thinning treatments in a Sierra Nevada mixed-conifer forest, USA. Forest Ecology and Management. 256(1-2): 168-179. doi:10.1016/j.foreco.2008.04.022

Zarnoch, S.J.; Blake, J.I.; Parresol, B.R. 2014. Are prescribed fire and thinning dominant processes affecting snag occurrence at a landscape scale? Forest Ecology and Management. 331: 144-152. doi:10.1016/j.foreco.2014.08.007

Zausen, G.L.; Kolb, T.E.; Bailey, J.D.; Wagner, M.R. 2005. Long-term impacts of stand management on ponderosa pine physiology and bark beetle abundance in northern Arizona: a replicated landscape study. Forest Ecology and Management. 218(1-3): 291-305. doi:10.1016/j.foreco.2005.08.023

Zhang, J.; Ritchie, M.W.; Oliver, W.W. 2008. Vegetation responses to stand structure and prescribed fire in an interior ponderosa pine ecosystem. Canadian Journal of Forest Research. 38(5): 909-918. doi:10.1139/X07-230

Zhang, J.; Oliver, W.W.; Ritchie, M.W.; Neal, D.L. 2013a. Overstory and understory dynamics in a ponderosa pine plantation vary with stand density in the Sierra Nevada: 40-year results. Forest Science. 59(6): 670-680. doi: 10.5849/forsci.10-033

Zhang, J.; Oliver, W.W.; Powers, R.F. 2013b. Reevaluating the self-thinning boundary line for ponderosa pine (*Pinus ponderosa*) forests. Canadian Journal of Forest Research. 43(10): 963-971. doi:10.1139/cjfr-2013-0133

Zhang, J.; Ritchie, M.W.; Maguire, D.A.; Oliver, W.W. 2013c. Thinning ponderosa pine (*Pinus ponderosa*) stands reduces mortality while maintaining stand productivity. Canadian Journal of Forest Research. 43(4): 311-320. doi:10.1139/cjfr-2012-0411

Zhang, J.; Young, D.H.; Luckow, K.R. 2015. Effect of redistributing windrowed topsoil on growth and development of ponderosa pine plantations. Forest Ecology and Management. 353: 148-155. doi:10.1016/j.foreco.2015.05.039

Zhang, J.; Webster, J.; Young, D.H.; Fiddler, G.O. 2016. Effect of thinning and soil treatments on Pinus ponderosa plantations: 15-year results. Forest Ecology and Management. 368: 123-132. doi:10.1016/j.foreco.2016.03.021

Zhang, J.; Finley, K.A.; Johnson, N.G.; Ritchie, M.W. 2019. Lowering stand density enhances resiliency of ponderosa pine forests to disturbances and climate change. Forest Science. 65(4): 496-507. doi:10.1093/forsci/fxz006

Zhang, J.; Busse, M.D.; Fiddler, G.O.; Fredrickson, E. 2019. Thirteen-year growth response of ponderosa pine plantations to dominant shrubs (Arctostaphylos and Ceanothus). Journal of Forestry Research. doi:10.1007/s11676-019-00945-6

Zhao, D.; Bullock, B.P.; Montes, C.R.; Wang, M. 2020. Rethinking maximum stand basal area and maximum SDI from the aspect of stand dynamics. Forest Ecology and Management. 475: 118462 (10 p). doi:10.1016/j.foreco.2020.118462

Ziegler, J.P.; Hoffman, C.; Battaglia, M.; Mell, W. 2017a. Spatially explicit measurements of forest structure and fire behavior following restoration treatments in dry forests. Forest Ecology and Management. 386: 1-12. doi:10.1016/j.foreco.2016.12.002

Ziegler, J.P.; Hoffman, C.M.; Fornwalt, P.J.; Sieg, C.H.; Battaglia, M.A.; Chambers, M.E.; Iniguez, J.M. 2017b. Tree regeneration spatial patterns in ponderosa pine forests following stand-replacing fire: Influence of topography and neighbors. Forests. 8(10): 391 (15 p). doi:10.3390/f8100391

Zimmerman, G.T. 2003. Fuels and fire behavior. Chapter 8. In: Friederici, P., ed. Ecological restoration of southwestern ponderosa pine forests. Washington, DC: Island Press: 126-143. isbn:1-55963-653-X

Zimmerman, G.T.; Laven, R.D. 1987. Effects of forest fuel smoke on dwarf mistletoe seed germination. Great Basin Naturalist. 47(4): 652-659. https://scholarsarchive.byu.edu/gbn/vol47/iss4/26

Zimmerman, G.T.; Neuenschwander, L.F. 1983. Fuel-load reductions resulting from prescribed burning in grazed and ungrazed Douglas-fir stands. Journal of Range Management. 36(3): 346-350. https://journals.uair.arizona.edu/index.php/jrm/article/download/7537/7149

Zimmerman, G.T.; Neuenschwander, L.F. 1984. Livestock grazing influences on community structure, fire intensity, and fire frequency within the Douglas-fir/ninebark habitat type. Journal of Range Management. 37(2): 104-110. https://journals.uair.arizona.edu/index.php/jrm/article/download/7680/7292

Zlatnik, E.J.; DeLuca, T.H.; Milner, K.S.; Potts, D.F. 1999. Site productivity and soil conditions on terraced ponderosa pine sites in western Montana. Western Journal of Applied Forestry. 14(1): 35-40. doi:10.1093/wjaf/14.1.35

Zon, R. 1907. A new explanation of the tolerance and intolerance of trees. Proceedings of the Society of American Foresters. 2(3): 79-94. http://books.google.com/books?id=tDUCAAAAYAAJ&oe=UTF-8

Zwieniecki, M.A.; Newton, M. 1995. Roots growing in rock fissures: Their morphological adaptation. Plant and Soil. 172(2): 181-187. doi:10.1007/BF00011320

Zwieniecki, M.A.; Newton, M. 1996. Seasonal pattern of water depletion from soil–rock profiles in a Mediterranean climate in southwestern Oregon. Canadian Journal of Forest Research. 26(8): 1346-1352. doi:10.1139/x26-150

Zwolak, R.; Pearson, D.E.; Ortega, Y.K.; Crone, E.E. 2010. Fire and mice: Seed predation moderates fire's influence on conifer recruitment. Ecology. 91(4): 1124-1131. doi:10.1890/09-0332.1

APPENDIX 5: SILVICULTURE WHITE PAPERS

White papers are internal reports, and they are produced with a consistent formatting and numbering scheme – all papers dealing with Silviculture, for example, are placed in a silviculture series (Silv) and numbered sequentially. Generally, white papers receive only limited review and, in some instances pertaining to highly technical or narrowly focused topics, the papers may receive no technical peer review at all. For papers that receive no review, the viewpoints and perspectives expressed in the paper are those of the author only, and do not necessarily represent agency positions of the Umatilla National Forest or the USDA Forest Service.

Large or important papers, such as two papers discussing active management considerations for dry and moist forests (white papers Silv-4 and Silv-7, respectively), receive extensive review comparable to what would occur for a research station general technical report (but they don't receive blind peer review, a process often used for journal articles).

White papers are designed to address a variety of objectives:

(1) They guide how a methodology, model, or procedure is used by practitioners on the Umatilla National Forest (to ensure consistency from one unit, or project, to another).

(2) Papers are often prepared to address ongoing and recurring needs; some papers have existed for more than 20 years and still receive high use, indicating that the need (or issue) has long standing – an example is white paper #1 describing the Forest's big-tree program, which has operated continuously for 25 years.

(3) Papers are sometimes prepared to address emerging or controversial issues, such as management of moist forests, elk thermal cover, or aspen forest in the Blue Mountains. These papers help establish a foundation of relevant literature, concepts, and principles that continuously evolve as an issue matures, and hence they may experience many iterations through time. [But also note that some papers have not changed since their initial development, in which case they reflect historical concepts or procedures.]

(4) Papers synthesize science viewed as particularly relevant to geographical and management contexts for the Umatilla National Forest. This is considered to be the Forest's self-selected 'best available science' (BAS), realizing that non-agency commenters would generally have a different conception of what constitutes BAS – like beauty, BAS is in the eye of the beholder.

(5) The objective of some papers is to locate and summarize the science germane to a particular topic or issue, including obscure sources such as master's theses or Ph.D. dissertations. In other instances, a paper may be designed to wade through an overwhelming amount of published science (dry-forest management), and then synthesize sources viewed as being most relevant to a local context.

(6) White papers function as a citable literature source for methodologies, models, and procedures used during environmental analysis – by citing a white paper, specialist reports can include less verbiage describing analytical databases, techniques, and so forth, some of which change little (if at all) from one planning effort to another.

(7) White papers are often used to describe how a map, database, or other product was developed. In this situation, the white paper functions as a 'user's guide' for the new product. Ex-

amples include papers dealing with historical products: (a) historical fire extents for the Tucannon watershed (WP Silv-21); (b) an 1880s map developed from General Land Office survey notes (WP Silv-41); and (c) a description of historical mapping sources (24 separate items) available from the Forest's history website (WP Silv-23).

The following white papers are available from the Forest's website: Silviculture White Papers

Paper #	Title
1	Big tree program
2	Description of composite vegetation database
3	Range of variation recommendations for dry, moist, and cold forests
4	Active management of Blue Mountains dry forests: Silvicultural considerations
5	Site productivity estimates for upland forest plant associations of Blue and Ochoco Mountains
6	Blue Mountains fire regimes
7	Active management of Blue Mountains moist forests: Silvicultural considerations
8	Keys for identifying forest series and plant associations of Blue and Ochoco Mountains
9	Is elk thermal cover ecologically sustainable?
10	A stage is a stage is a stage…or is it? Successional stages, structural stages, seral stages
11	Blue Mountains vegetation chronology
12	Calculated values of basal area and board-foot timber volume for existing (known) values of canopy cover
13	Created opening, minimum stocking, and reforestation standards from Umatilla National Forest Land and Resource Management Plan
14	Description of EVG-PI database
15	Determining green-tree replacements for snags: A process paper
16	Douglas-fir tussock moth: A briefing paper
17	Fact sheet: Forest Service trust funds
18	Fire regime condition class queries
19	Forest health notes for an Interior Columbia Basin Ecosystem Management Project field trip on July 30, 1998 (handout)
20	Height-diameter equations for tree species of Blue and Wallowa Mountains
21	Historical wildfires in headwaters portion of Tucannon River watershed
22	Range of variation recommendations for insect and disease susceptibility
23	Historical vegetation mapping
24	How to measure a big tree
25	Important Blue Mountains insects and diseases
26	Is this stand overstocked? An environmental education activity
27	Mechanized timber harvest: Some ecosystem management considerations
28	Common plants of south-central Blue Mountains (Malheur National Forest)
29	Potential natural vegetation of Umatilla National Forest

Paper #	Title
30	Potential vegetation mapping chronology
31	Probability of tree mortality as related to fire-caused crown scorch
32	Review of "Integrated scientific assessment for ecosystem management in the interior Columbia basin, and portions of the Klamath and Great basins" – Forest vegetation
33	Silviculture facts
34	Silvicultural activities: Description and terminology
35	Site potential tree height estimates for Pomeroy and Walla Walla Ranger Districts
36	Stand density protocol for mid-scale assessments
37	Stand density thresholds as related to crown-fire susceptibility
38	Umatilla National Forest Land and Resource Management Plan: Forestry direction
39	Updates of maximum stand density index and site index for Blue Mountains variant of Forest Vegetation Simulator
40	Competing vegetation analysis for southern portion of Tower Fire area
41	Using General Land Office survey notes to characterize historical vegetation conditions for Umatilla National Forest
42	Life history traits for common Blue Mountains conifer trees
43	Timber volume reductions associated with green-tree snag replacements
44	Density management field exercise
45	Climate change and carbon sequestration: Vegetation management considerations
46	Knutson-Vandenberg (K-V) program
47	Active management of quaking aspen plant communities in northern Blue Mountains: Regeneration ecology and silvicultural considerations
48	Tower Fire…then and now. Using camera points to monitor postfire recovery
49	How to prepare a silvicultural prescription for uneven-aged management
50	Stand density conditions for Umatilla National Forest: A range of variation analysis
51	Restoration opportunities for upland forest environments of Umatilla National Forest
52	New perspectives in riparian management: Why might we want to consider active management for certain portions of riparian habitat conservation areas?
53	Eastside Screens chronology
54	Using mathematics in forestry: An environmental education activity
55	Silviculture certification: Tips, tools, and trip-ups
56	Vegetation polygon mapping and classification standards: Malheur, Umatilla, and Wallowa-Whitman National Forests
57	State of vegetation databases for Malheur, Umatilla, and Wallowa-Whitman National Forests
58	Seral status for tree species of Blue and Ochoco Mountains

REVISION HISTORY

July 2011: initial version of this white paper was circulated for technical peer review by Rick Brown (Defenders of Wildlife), Craig Schmitt (USDA Forest Service, Blue Mountains Service Center, La Grande), and Carrie Spradlin (USDA Forest Service, Umatilla National Forest, Heppner Ranger District). Their reviews contributed significantly to this white paper!

July 2012: minor formatting and editing changes were made (renumbered section headings and figure captions); a new section (7.11) providing selected wildlife considerations was added, along with additional literature citations.

November 2012: minor formatting and editing changes were made throughout the document; the References section was corrected; appendix 2 was added describing the silviculture white paper system, including a list of available white papers.

April 2013: minor formatting and editing changes were made throughout the document; new text (a quote) was added to section 3.1; additional text and a new figure were added to the ungulate herbivory discussion (section 5); a new figure was added to the climate change discussion (section 7.13).

January 2014: this was a significant update: formatting and editing changes were made throughout the document, including a renumbering of all subsections within section 7; additional photographs were added (livestock grazing, selective cutting, and restoration sections); new material was added about dry-forest stocking levels and how they could be applied (figs. 30-32 and table 6); a new figure was added describing western juniper expansion on dry sites; and a Summary section was added before the References section.

December 2014: minor formatting and editing changes were made, including the addition of new photographs as figures; a new appendix 2 was added describing early 1940s timber harvest practices in the Blue Mountains by using a series of photographs from Grant County and the Malheur National Forest; a new appendix 3 was added providing regeneration monitoring results for 76 plots established on dry upland forest sites on the Umatilla National Forest; and additional references were added to the References section, along with weblinks and digital object identifiers (doi) to improve access to more dry-forest references.

August 2020: minor formatting and editing changes were made throughout the document; a new appendix 4 was added providing discussion and rationale for reducing representation of grand fir and Douglas-fir on dry-forest sites, especially for large (≥ 21" dbh) and young (< 150 years abh) grand firs and Douglas-firs located within a 2-dripline distance of desirable trees. Many additional references were added during this revision, primarily to bring the literature somewhat up to date for items published after 2014, and to add additional literature pertaining to non-mechanical dry-forest treatments such as prescribed fire. An Index was also added during this revision.

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